THE

ARCHITECTURE

OF

M·VITRUVIUS·POLLIO:

TRANSLATED

FROM THE ORIGINAL LATIN,

BY

W. NEWTON, ARCHITECT.

VOLUME THE SECOND.

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ADVERTISEMENT.

IT is many years ſince I publiſhed a Tranſlation of the firſt five books of Vitruvius; intending, if it met with approbation, to tranſlate the remaining part of that Author. Having the ſatisfaction to find the work approved, I have been induced to proceed with it, as my intervals of leiſure permitted: but the requiſite attention to the duties of my profeſſion, and a very precarious ſtate of health, have retarded its progreſs. And, during the laſt eight years, the erection of the new Chapel in Greenwich Hoſpital* has ſo fully occupied my time, as to allow me no opportunity of attending to this work. In proceeding with the tranſlation of the latter books of Vitruvius, ſome additional explanations, emendations, or remarks relative to the former have occurred. Part of theſe could be moſt conveniently fixed in the places to which they belong; they are therefore printed ſeparately for that purpoſe, and will be given to the purchaſers with the ſecond part of the work. The reſt are annexed in form of an Appendix. An Index is adjoined, numbered according to the books and chapters; by which means it will ſuit not only this, but in a great meaſure all other tranſlations and editions of Vitruvius.

WILLIAM NEWTON.

* In a work lately publiſhed, intitled *An Hiſtorical Account of the Royal Hoſpital for Seamen at Greenwich*, it may be obſerved (at p. 100) that the deſigning of the new chapel is aſcribed ſolely to the late Mr. Stuart. The reſpect which is due to truth, and a reputation fairly earned, obliges me to notice that aſſertion, and to embrace this opportunity of ſtating the caſe to thoſe who may think ſo trifling a circumſtance worthy of attention. In the year 1782, when the chapel was begun, Mr. Stuart was far advanced in age; and had, for many years preceding his death, been extremely infirm. On this occaſion therefore, which called for a union of experience and activity, I was authoriſed by the Directors of the Hoſpital to aſſiſt him. The general deſigns for the chapel I made that year; and continued to produce the reſt, from time to time, until its completion in 1790, two years after Mr. Stuart's death. The only parts of the building in which Mr. Stuart had any ſhare, were the ornaments of the cieling, the frame of the altar-picture, and the baluſters uſed in the two ſide galleries: theſe, with the carving of ſome ſtone mouldings, taken from Greek examples in his Antiquities of Athens, were all that he determined; the remainder were of my deſigning, or my ſelecting, where the antique has been ſelected. This being the fact, and the building having obtained ſome commendation, I conceive myſelf juſtified in thus publicly aſſerting my claim to a ſhare of the work; although I at the ſame time become reſponſible for a greater portion of its errors. I do not mean to charge the authors of the above-mentioned *Hiſtorical Account* with any deliberate intention to injure my fame, or deprive me of what little reputation I may deſerve: their book was publiſhed under the ſanction of the Governors of the Hoſpital. Mr. Stuart was the regular ſurveyor, whoſe duty it was to provide whatever architectural deſigns may be required; and therefore the laws and forms of that eſtabliſhment were complied with, in his appearing oſtenſibly to be the deſigner of that edifice, and alſo of the new building appropriated to the education of the charity boys, although it was entirely executed from my deſigns.

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THE

ARCHITECTURE

OF

M·VITRUVIUS·POLLIO.

BOOK THE SIXTH.

PROEM.

ARISTIPPUS the Socratic Philoſopher, when ſhipwrecked on the coaſt of Rhodes, obſerving ſome geometrical figures there deſcribed, is ſaid to have called to his companions thus: "Rejoice! for I ſee the ſigns of men!" and immediately ſought his way to the city of Rhodes; where going directly to the Gymnaſium[1*], and diſcourſing on philoſophy, he was ſo enriched with preſents as not only to ſupply himſelf, but alſo all thoſe who accompanied him, with apparel and other neceſſaries of life. When his companions intended to return to their own country, they aſked him what he would have them ſay to their countrymen; upon which he bade them ſay that the poſſeſſions and endowments they provided for their children ought to be ſuch as would relieve them even from the diſtreſſes attending ſhipwreck; for ſuch were the true ſupports of life, which neither the adverſe blaſts of fortune, the changes of public affairs, nor the devaſtation of war, could affect. Theophraſtus alſo, enlarging on the proverb, that the learned, rather than the rich, ought to be honoured, writes thus: The learned only, either when travelling in foreign countries, or under the loſs

(1*) Galiani here obſerves that the word Gymnaſium is no where elſe mentioned by Vitruvius; which muſt be an overſight: for it is mentioned in the laſt chap. of the firſt, and in the fifth chap. of the ſeventh Book.

of relations and neceſſaries, are in no want of friends, but are citizens in all cities, and may fearleſsly deſpiſe the accidents of fortune: but he who is ignorant, and thinks himſelf ſecured by his wealth, walks on ſlippery paths, and paſſes an uncertain and hazardous life. Epicurus in like manner ſays, the wiſe are rarely indebted to fortune, becauſe all things that are eſſentially neceſſary are within the command of the mind and underſtanding.

As many of the philoſophers have thus argued, ſo likewiſe the poets, who have written the antient Grecian dramas, have pronounced on the ſtage the ſame ſentiments in verſe; as Euchrates, Chionides, Ariſtophanes, and above all Alexis, who ſays, the Athenians deſerve particularly to be commended, becauſe, whereas the laws of the Greeks oblige all children to ſupport their parents, the Athenians confine it to thoſe only who have inſtructed their children in ſome art: for of all the gifts of fortune they may be eaſily deprived; whereas knowledge, united with the mind, never fails, but remains fixed to the utmoſt verge of life.

I therefore have great and infinite obligations to my parents, who, approving the Athenian laws, took care to have me inſtructed in an art; and that one, which cannot be well practiſed without ſome knowledge of literature and the ſciences. Having then, by the care of my parents, and the inſtruction of my preceptors, the means of acquiring knowledge, and being pleaſed with literary and philoſophical ſubjects, I ſtored my mind with theſe poſſeſſions, of which the advantage is, the never more being in want: and it is the great advantage of riches to want for nothing. But perhaps there are ſome who, judging erroneouſly, may think thoſe only are ſkilful who are rich: for which reaſon, many aiming only at that end, by joining aſſurance with riches, have obtained reputation. But I have not, O Cæſar, endeavoured to obtain wealth by my art, having preferred a little, with a good name, to an abundance, attended with infamy: ſmall therefore is the fame I have obtained; yet by theſe volumes I hope to be known to poſterity.

Nor is it to be wondered at that I may be to many unknown: other architects ſolicit and make intereſt to be employed; but I have learnt from authors that it is proper to be requeſted, not to requeſt, to be entruſted. Beſides, the ingenuous bluſh and are ſtruck with ſhame in aſking a favour; for the givers, not the receivers, of benefits are courted. But what can we think muſt be ſuſpected by him who is requeſted to entruſt another with the care of his property, but that the other's gain and emolument is the cauſe of the requeſt? The antients therefore committed their works to ſuch architects only as were of approved families, enquiring whether they had been well educated and were ingenuous and modeſt; judging the bold and arrogant not fit to be truſted. The artiſts themſelves alſo inſtructed none but their own children or kindred, and brought them up honeſt men, to whom things of value might be ſafely committed. When therefore I obſerve the illiterate and unſkilful pretend

to ſuch an art, who not only of architecture, but of every thing relative to fabrics, are ignorant; I cannot blame thoſe fathers of families who, confiding in their own knowledge, manage their buildings themſelves; judging that, if they muſt be committed to the unſkilful, it is better to ſpend their money according to their own pleaſure, than that of another. Hence it is, that no one attempts to practiſe at home any other art (as that of a ſhoe-maker, fuller, or others yet more eaſy), except that of architecture; becauſe many who profeſs it, are not really ſkilled in the art, but are falſely called architects.[1*]

For this reaſon I have been induced to write a treatiſe of Architecture, and the principles thereof, believing the gift will to all people be acceptable. As then in the fifth book I have written of the conſtruction of public works, in this I ſhall explain the principles and proportions of private edifices.

(*) By this paſſage we learn that the famous Vitruvius, the father of the art, and chief fountain from whence we draw our preſent knowledge of the theoretical part of architecture, was in his own time neglected, and little employed. We alſo learn that then, as in our days, perſons unfounded and ignorant in the art aſſumed the name of Architects, and have obtained more employment and encouragement than thoſe who were well ſkilled in their profeſſion. This will probably ever be the caſe. For the habits of ſtudy by which knowledge is acquired, and perhaps the turn of mind and diffidence which, as Vitruvius ſays, generally accompanies men of ſenſibility and merit, unfits them for dealing with the world; they are either aſhamed, or diſdain to make uſe of that craft, political cunning, and ſervility, which, according to the ſtate of mankind in ſome ages, are the neceſſary ſteps to ſucceſs. On the contrary, thoſe who have ſpent their time, not in their ſtudy, but in the world, habitually acquire that confidence which, notwithſtanding the diſcovery of their ignorance, naturally prevails, and as naturally produces errors and evils as the conſequences.

It appears then it muſt be very accidental if men of merit are ſucceſsful. They cannot ſeek, they muſt be ſought; and there are few men who chooſe to take that trouble, finding it eaſier to yield to the ſolicitations of thoſe who aſk, than ſearch for thoſe who deſerve. The generality indeed are not able to diſcover the deſerving. But this might be expected from men of rank and fortune, from their ſuperior education, and who owe it as a duty to their country to promote its honour and intereſt. In them therefore the neglect of merit is more cenſurable, or their being impoſed on by the ignorant, more ſhameful.

Men of knowledge however muſt generally expect to be neglected, and be content with little, and the happy tranquillity of their ſtudy; or, if they deſire wealth and employment, forſake their ſtudies, and prepare for the doom that awaits them, the troubles that ever attend a great intercourſe with the world.

CHAPTER I.

Of the Diſpoſition of Buildings, according to the different Climates, and the various Aſpects of the Heavens.

FOR theſe to be properly conſtructed, the region or climate of the world in which they are to be erected ſhould be firſt conſidered:——Egypt requires one manner, Spain another, a different one at Pontus, another at Rome; and ſo of other countries and climates, the nature of which ſhould determine the ſtyle of the building: for ſome parts of the earth are annoyed by the heat of the ſun, ſome are too far from it, while others again are of a moderate temperature. As then, by the conſtitution of the world, the inclination of the zodiac, and the courſe of the ſun, the ſeveral parts of the earth are naturally of different temperatures; ſo the diſpoſition of buildings ſhould be regulated by the nature of the climates, and the various poſitions of the heavens. Edifices in the northern parts ſhould be vaulted and incloſed; not laid open, but turned to the warm aſpects: on the contrary, in the ſouthern regions, which are oppreſſed by the intenſe heat of the ſun, they ſhould be built open and expoſed to the north and eaſt; and thus the ill effects of nature may be corrected by art. Other climates alſo may be qualified by ſimilar means, according to the poſition of the heavens with regard to the earth. But theſe muſt be determined by obſervations on the nature of the place, as well as on the members and bodies of the inhabitants: for in places where the ſun moderately ſheds his beams, the natives are of a temperate conſtitution; where it ſhines vehemently, it exudes and deſtroys the temperature of the humours; and, on the contrary, in the frigid regions, which are far diſtant from the ſouth, the humidity not being exhaled by heat, the dampneſs of the atmoſphere infuſes watery humours in the inhabitants, and cauſes them to have larger bodies and baſer voices: this is the reaſon that the northern people are of huge ſtature, white colour, have ſtraight and red hair, grey eyes, and much blood; all which are occaſioned by the abundance or moiſture and coldneſs of the air: while thoſe who live near the meridian axis (equator) under the line of the ſun, are of ſmaller ſtature, ſwarthy colour, having curled hair, black eyes, weak legs, and a ſmall portion of blood, owing to the violent heat of the ſun: having therefore but a ſmall quantity of blood, they are more timid in war, but will endure heat and fevers without fear, becauſe their bodies are nouriſhed by heat; while the people who are born in the northern climates are more fearful of, and affected by, fevers; but, being replete with blood, are undaunted in war.

Nor is there leſs difference and variety in the ſounds of the voices of different nations; for at the limits of the eaſt and weſt, near the equidiviſion of the earth, where the ſuperior

part of the world is divided from the inferior, there appears to be naturally a level circle, which the mathematicians call *horizonta:* retaining this in mind, from the edge which is in the northern region, ſuppoſe a line to be drawn to that which is in the meridian axis,[1*] from whence another oblique line is drawn up to the cardinal point (the pole) which is at the north ſtar; we ſhall then obſerve that this forms a triangular figure ſimilar to the inſtrument which the Greeks call *ſambucen.*[2*] Now as this oblique line, near its termination in the meridian axis, is but little diſtant from the baſe, the tone of voice of the people dwelling in thoſe parts, on account of the ſmall elevation of the pole, is exceedingly ſhrill and acute; as is the tone of that part of the ſtringed inſtrument which is near the angle. Thoſe who inhabit the middle part about Greece, abate in the acuteneſs of their voices. Proceeding from the middle to the extremity under the northern ſkies, the ſpeech of the people gradually becomes more and more baſe. Thus it appears that the whole world, by the due declination and temperature of the ſun, is conſtituted harmonically; and hence the people who inhabit the middle parts between the meridian axis and the northern regions have, as in the muſical ſcale, a moderate tone of voice. Advancing northward, as the pole has a greater elevation, ſo the people being fuller of moiſture have naturally baſer voices, like the ſounds of *hypatos* and *proſlambanomenos.* And for the ſame reaſon, from the middle parts towards the ſouthern nations, the voices of the people are more ſhrill, like the acute ſound of paranete.

That the voice is rendered baſer by the humid nature of a place, and more acute by its fervidity, may be thus experienced. Take two veſſels equally burnt, in the ſame furnace, of equal weight and yielding the ſame ſound: immerſe one of theſe in water, and when it is taken out, upon ſtriking both there will be perceived a great difference in their ſounds, nor will they be of the ſame weight. So it is with human bodies, although of the ſame ſhape and born under the ſame conjunctions of the planets: ſome, on account of the heat of the climate, ſpeak in an acute tone; while others, from the abundance of moiſture, utter the loweſt degrees of ſound. The clearneſs of the atmoſphere alſo, owing to the fervent heat, renders the ſouthern people quick of mind and ready in devices; but the northern nations, who breathe a groſs atmoſphere, have, on account of the cold humidity of the air, more ob-

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(1*) By meridian axis, which I have rendered literally, it is evident that Vitruvius does not mean the ſouth pole, but ſome point in the equator, for he ſpeaks of it as being under the line of the ſun. He ſeems to have an idea, that the earth extended no farther ſouthward than the equator, and that Greece was ſituated about the middle between it and the moſt northern parts; ſo that the figure he deſcribes may be conceived thus:

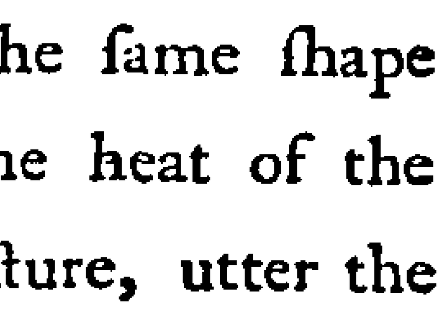
The circle ADB is the horizon.

A the edge in the northern region.

B that in the meridian axis, or equator.

C Media Græcia.

* the north ſtar.



(2*) Suppoſed by ſome to be a kind of harp, by others the ſyrinx or triangular ſet of reeds with which the god Pan is uſually repreſented; it is probably the former, as Vitruvius uſes the words organo chorda preſently after. At the laſt chapter of the tenth book it is again mentioned.

tuſe intellects. This may be obſerved by ſerpents, which, when the cold vapours are diſpelled by heat, move with vivacity; but at Brumalia,[3*] and in winter time, by the coldneſs of the air, they become ſluggiſh and ſtupid: it is therefore no wonder that the intellects of men ſhould be rendered more acute by the warmth of the air, and more heavy by its frigidity. But although the ſouthern people have the moſt acute intellects, and are extremely ſagacious in council, yet in courage they fail, the ſun abſorbing their ſpirits; while thoſe who are born in cold climates are prompt to the ardours of war, and without fear vigorouſly make their attacks; but having dull intellects, and ruſhing on without conſideration or judgment, their attempts are eaſily defeated.

Thus by the conſtitution of nature all nations differ, according to the variations of the climate; and it has ſo happened that the people of Rome poſſeſs the middle parts and regions of the whole earth, and for that reaſon the Italians have a due mixture, both of ſtrength of body, and vigour of mind. For as the planet Jupiter, which moves between the fervid orbit of Mars, and the cold orbit of Saturn,[4*] is of a due temperature: ſo the people of Italy being ſituated between the northern and ſouthern regions, and having a due mixture of both, have thoſe qualities that render them invincible; overcoming by ſagacity the force of the Barbarians, and by force the ſagacity of the ſouthern nations. The divine Mind has thus ſituated the city of the Roman people in an excellent and temperate climate, that they might poſſeſs the empire of the whole earth. Since then the ſeveral parts of the earth are, from the inclination of the heavens, of various temperatures, and the inhabitants are, by nature, accordingly varied in the qualities of their minds as well as in the figure of their bodies, we can have no doubt but that the diſtribution of buildings ſhould alſo be adapted to the qualities of the different countries and people, as it is, by Nature herſelf, wiſely and plainly indicated.

Thus I have explained, as well as I have been able, the chief rules regarding ſituations according to the nature of things, and have ſpoken of the ſuitableneſs of edifices to the different conſtitutions of the people, occaſioned by the poſition of the ſun, and declination of the heavens: I ſhall now therefore briefly treat of the ſeveral kinds of ſymmetry to be uſed in buildings, as well in the whole, as in their ſeparate parts.

(3*) Brumalia was the time of the feaſts of Bacchus, celebrated at the beginning and end of winter, one on the 15th of Auguſt, and the other on the laſt day of February.

(4*) The antient planetary ſyſtem muſt here again be recollected, which placed the Earth at reſt in the center, the Sun and the other planets moving round it in the order following: 1ſt, the Moon; 2d, Mercury; 3d, Venus; 4th, the Sun; 5th, Mars; 6th, Jupiter; and 7th, Saturn: ſo that, according to this ſyſtem, the orbit of Mars was next to that of the Sun, and therefore ſuppoſed to be in a great degree of heat.

CHAPTER II.

Of the Proportions of private Buildings.

NOTHING ought to be more the care of an Architect, than that the several parts of an edifice be in exact proportion; when therefore the kind of symmetry and the magnitudes are settled, it is then the part of the judgment to adapt them to the nature of the place, the use, or the species, and, by diminution or addition, to qualify the symmetry, till it appears rightly adjusted, and leaves nothing defective in the appearance. For some objects are to be viewed near, others elevated; some are inclosed, others exposed; in all which, great judgment is required to modify them so that at last the work may be perfect: for the sight does not always inform justly, but often differs from the judgment; as in painted scenes, where columns, mutules, and statues, seem to project and be prominent, although they are undoubtedly flat planes.[1*] The oars of ships likewise, when under water, are really straight, notwithstanding they appear to the eye to be crooked; for the instant before their ends touch the surface of the water they appear straight, as they are; yet as soon as they are plunged into the water, by means of the transparent medium, their images are refracted toward the surface, and cause them to appear crooked; and whether this be owing to the impulse of the images, or to the divergence of the rays from the eyes, whichever philosophers will admit, we however find that either way the eyes are deceived.[2*] As then things may appear falsely, and may be different from what they seem to the eyes, I think it cannot be doubted, but that we should diminish or enlarge objects according to the nature of their situation, in order that no part of the work may be unsatisfactory; but this must be effected by the acuteness of genius, and cannot be taught by precepts.[3*]

(1*) This passage affords good reason for believing that the antients well understood the art of perspective, which some have doubted on account of the defective examples of it which have come to our knowledge. See also the Proem to the seventh book.

(2*) Vitruvius speaks according to the philosophy of his time in accounting for the crooked appearance of oars in the water; which is now known to be caused by the refraction of the rays of light passing through that denser medium.

(3*) The subject here treated of, viz. altering the usual proportions of objects when placed in some situations, or under some peculiar circumstances, is a point much contested.

In first determining or selecting the proportion to be given to an object, regard must undoubtedly be paid to its use, place, or other circumstances; but that being done, whether a deviation therefrom may on any account be proper, is the question.

The only, or chief, reason that occurs to me for such deviation, is that without it the object, when in its place,

The mode of the ſymmetry therefore being firſt fixed, the alterations are to be made thereon; then the length and breadth of the plans of the ſeveral parts of the intended work are to be determined, the magnitude of which being ſettled, the proportions are to be adjuſted according to the rules of decor,[4*] ſo that upon examination the eurithmy may not appear deficient. By what means this may be effected, it is my part to explain. And I ſhall firſt mention how cavædiums ſhould be conſtructed.

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would not appear of the required proportion, or figure; and that by the alteration (ſometimes even to diſtortion) the required appearance will be obtained.

In all common ſituations, to which the eye is accuſtomed, no deviation can be requiſite, for in ſuch caſes people have acquired by habit a power of allowing for appearances, perceive the real proportions of objects, and even ſee ideally the whole of members partly hidden from their view. Indeed in no ſituation do we ever ſee the whole of an object; for the projections of ſome parts always intercept the view of others: but we have acquired the power of allowing for the interception; we can change our place, and obſerve how the change affects the appearances of the members: we can alſo uſe the ſenſe of feeling in ſome caſes; and there may be other means that unobſervedly operate in enabling us to form a juſt idea of the proportions and figure of objects in familiar ſituations; in ſuch the circle appears to us truly circular, and the ſquare truly rectangular, notwithſtanding the obliquity of the view may make the viſual angle formed by one diameter leſs than that of the other.

But in all unuſual ſituations, in which the eye is inexperienced, ſome deviation may be proper; as, for inſtance, in extraordinary heights or diſtances; in caſes of intentional deception, where the view is confined to one ſpot, or ſome particular end is aimed at; when the expreſſion of character is attempted, and where parts are required to appear larger or leſs than they are in reality, and where a variation from the uſual dimenſions of the accompanying objects may produce the effect deſired. In uncommon heights alſo, the perpendicular ſurfaces being ſo much hidden by the horizontal projectures, it may be proper to leſſen the latter as well as to increaſe the former, or to incline them forward, as Vitruvius directs in the third chapter of the third book.

Such deviations I have myſelf frequently had occaſion to practiſe, and ſee the propriety of, particularly in the chapel of Greenwich Hoſpital, where the effects often ſingularly diſappointed the expectation, and demanded the deviations mentioned.

In theſe and ſuch adjuſtments no rules or precepts (as Vitruvius well obſerves) can avail: natural power of mind, improved by obſervation and practice, can alone ſucceed; and in this chiefly taſte, or the perception of beauty, propriety, and character, will be evident in the compoſer.

(4*) For the explanation of decor, ſee Book I. Chap. II.

CHAPTER III.

Of Cavædiums.

THERE are five diſtinct kinds of cavædiums,[1*] which from their forms are named thus, Tuſcan, Corinthian, Tetraſtyle, Diſpluviated, and Teſtudinated.

Fig. LIII. The Tuſcan kind are thoſe in which the beams (a a) that croſs the breadth of the atrium, have interpenſivæ[2*] (b b); and gutters (c c) proceeding from the angles of the walls to the angles of the joiſts; alſo from the aſſers (e) the eaves water is diſcharged into the middle compluvium[3*] (d d).

(1*) The term cavædium is derived from the words cava-ædium, and means courts or other void ſpaces within the body of a houſe.

(2*) Perrault has repreſented the interpenſivæ as diagonal props or braces, their lower ends reſting in the wall, and their upper ends ſupporting the eaves projected forward: but this is not reconcileable to the words of the text, in the deſcription of the tetraſtyle cavædium; " utilitatem trabibus & firmitatem præſtant, quod neque " ipſæ magnum impetum coguntur habere, neque ab " interpenſivis onerantur;" which imply that the interpenſivæ were things ſupported, not ſupports; and alſo that they were not ſituated under the beams, but reſted upon them. Perrault would interpolate the text in order to make it bear his conſtruction, by adding *parietibus* after *trabibus*, and thus transferring the alluſion of the paſſage from the beams to the walls.

Galiani is of opinion that the interpenſivæ were two beams that laid lengthways of the cavædium over the two beams that laid breadthways; and has tranſlated the text accordingly. But as in ſuch a caſe the beams on two ſides of the cavædium would lie higher than thoſe on the other two ſides, the columns that ſupported thoſe beams in the Corinthian cavædiums (which are deſcribed to be the ſame as the Tuſcan, with only the addition of columns around) would alſo be of different heights; which is an irregularity ſo unuſual that it cannot be admitted. Beſides, Vitruvius has in other places deſcribed the beams by the term *trabes*, and it is not likely that in this place only he ſhould have called them interpenſivæ.

Philander ſuppoſes the interpenſivæ to be the joiſts or timbers (b b) that were laid from the wall to the beams (a a) Fig. LIII. and LIV. which is alſo my opinion, excepting that I believe the word was confined in its application to thoſe caſes where the ſaid joiſts projected beyond the beams, forming what we now call conſoles, or cantilivers, as in the Tuſcan order according to the deſcription of Vitruvius. But Perrault alleges, in oppoſition to the opinion of Philander, that the interpenſivæ are deſcribed to proceed from the angles of the walls to the angles of the joiſts (tignæ): that I think is not the caſe, as the words of the text may, and I believe do, allude to the gutters *(colliquias)*, and not to the interpenſivæ.

Perrault alſo differs from all the other tranſlators in his acceptation of the word *colliquias*, which he has rendered *the coyers*, i. e. the rafters that are placed at the angles of roofs; but it is highly probable that it ſignifies ſome kind of gutters or channels, as it is generally underſtood. Columella, 2. 8. uſes it in that ſenſe, and Pliny, 18. 19. writes collicias (as it is alſo written in ſome manuſcripts of Vitruvius) in the ſame ſignification.

(3*) Barbaro and Galiani ſuppoſe the compluvium to be a reſervoir made in the middle of the pavement of the cavædium, but in the diſpluviated cavædium it is ſaid the compluviums being erect intercept not the light from the apartments. Which words forbid ſuch a ſuppoſition, and ſhew that the compluvium muſt be above the windows. Perrault judges it to be the gutter (d d) at the eaves where the rain water from the whole roof is collected; and this opinion ſeems to me to be juſt, and is

Fig. LVII. and LVIII. In the Corinthian cavædium, the beams and compluvium are diſpoſed in the ſame manner; but as the beams project from the walls, columns are arranged in the circuit around.

Fig. LIV. The tetraſtyle are thoſe wherein columns (g g) are placed under the beams at the angles, giving ſtrength and ſupport to thoſe beams; for by this means they are neither ſtrained by their own great length, nor are they depreſſed by the interpenſivæ.

Fig. LV. The diſpluviated are ſuch in which the eaves that ſupport the incloſure of the gutters (deliquiæ)[4*] return backward: theſe are chiefly uſeful in winter apartments, becauſe their compluviums (a a) being erect, intercept not the light from the rooms; but they have great inconveniences with regard to reparation, for the pipes (b b) that receive the water flowing from the eaves, being againſt the walls, and not receiving quickly enough the deſcending water from the gutters, it overflows and damages the internal work and walls in theſe kind of buildings.

Fig. LVI. The teſtudinated are made where the ſpan (impetus) is not very great; and ſpacious apartments are erected in the floors above them.

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corroborated by the following paſſage in Varro, book the 4th. "In cavædio ſi locus nullus relictus erat ſub divo "qui eſſet, dicebatur teſtudo: ſi relictus erat in medio "ut lucem caperet deorſum qua impluebat, impluvium "dictum—& ſurſum qua confluebat, compluvium."—"In "the cavædium, if no part be left uncovered, it is called "teſtudo; if left uncovered in the middle to admit the "light, the place through which the rain falls is called im-"pluvium; and above where it flows together is called "compluvium." From the compluvium (d d) the water muſt have been diſcharged through the ſpouts uſually formed in the ſima of the cornice in the ſhape of lions' heads, and either retained in a reſervoir made in the middle of the cavædium, or carried off by drains. But in the diſpluviated cavædiums the compluvium, which is ſaid to be erect, may have been placed on the top of the wall and behind the parapet; the water being brought down by perpendicular pipes fixed within or againſt the face of the wall, as is our preſent practice.

(4*) The tranſlators in general (led probably by the comment of Philander) have underſtood the word *deliquiæ* in this place to ſignify ſome timbers of the roof or eaves, as Perrault has underſtood *colliquias*. But I cannot help being of opinion that both theſe words ſignify ſome kind of gutters, and that even from the very paſſage that Philander quotes from Sext. Pompeius. This author uſes the words *collitias* and *delitias* in the ſame ſenſe, and ſays the *collitias tegulas* were a kind of tiles by which water was conveyed into veſſels; they therefore muſt have been a ſort of gutter-tiles to anſwer that end: and this evidently ſhews the ſignification of the word *collitia*, and conſequently of *deliquia*.

CHAPTER IV.

Of the Atrium, Alæ, Tablinum and Periſtylium, with their Dimenſions and Symmetry.

THE length and breadth of atriums[1*] are regulated in three manners: the firſt is, when the length being divided into five parts, three parts are given to the breadth; the other is, when divided into three parts, two parts are allowed to the breadth; and the third is, when a ſquare of equal ſides being formed on the breadth, and in that ſquare a diagonal line drawn, the length of the atrium is made equal to that diagonal line; their height, to the

(1*) Whether Vitruvius means the ſame place by the words *atrium* and *cavædium* is a point that has never yet been decided. Perrault believes them to be different apartments, Galiani aſſerts they are one and the ſame, and Barbaro and Palladio are of the latter opinion.

Perrault alleges that atriums are deſcribed by Vitruvius to have alæ on the right and left, which has no ſimilarity to any one of the five ſorts of cavædiums he deſcribes.

Galiani founds his opinion on Vitruvius uſing the word *atrium* in deſcribing the Tuſcan *cavædium*, and his omitting to give the proportions of cavædiums till he treats of them in this chapter under the name of atriums, alſo on his mentioning in one paſſage at chap 8. *veſtibula, cavæ-ædium, periſtylia*; and again in another paſſage, *veſtibula regalia, alta atria, & periſtylia*; in which paſſages, *cavædium* in one, has the ſame place as *atria* has in the other: Vitruvius alſo, he alleges, begins the chapter on atriums as if it were the continuation of the ſubject he had been treating of in the foregoing chapter: Atriorum vero longitudines, &c.

This ſubject ſeems not ſufficiently explained by Vitruvius to admit of a ſatisfactory deciſion. I ſhall however mention ſuch obſervations as have occurred to me thereon. Cavædiums, as their name imports, were covered or open areas, within the body of the houſe, from which (when open) the apartments around received their light, as Vitruvius intimates in the deſcription of the diſpluviated cavædium. Whereas atriums were always placed near the gate, as mentioned at the 8th chapter following. Atriums are alſo deſcribed, as Perrault obſerves, with alæ on the right and left ſides only, but cavædiums are ſaid to be ſometimes without columns, and conſequently without alæ; ſometimes with columns, and alæ of courſe, all around, and ſometimes with columns only at the four angles; nor are any deſcribed of a form that can be ſaid to have alæ on the two ſides only. The alæ of atriums are deſcribed to be no higher than they are broad; but the alæ of cavædiums, by their conſtruction, muſt have two, three, or four times their breadth in height. Atriums had an aperture in the ceiling of an aſſigned proportion to give light; but of cavædiums, ſome are deſcribed to be entirely covered, and ſome wholly uncovered. The forms of cavædiums that have columns will not agree with the proportions of atriums, as here given, as will be noticed hereafter, without rendering them incommodious and ſcarcely paſſable. Laſtly, Pliny in the deſcription of his villa at Laurentinum mentions its having both an atrium and cavædium: " In prima " parte *atrium* frugi, nec tamen ſordidum, deinde porticus " in O literæ ſimilitudinem circumactæ,.....eſt contra me- " dias *cavædium* hilare;" which is a ſtrong evidence that theſe terms ſignified different places.

The reaſon that Vitruvius does not ſpeak of the proportions of cavædiums may be becauſe they had no fixed proportion, being governed entirely by the diſtribution of the apartments of the houſe, and were longer or ſhorter, larger or ſmaller, juſt as thoſe apartments required.

Perrault has made a miſtake in his plan P. LIII. having placed the cavædium near the entrance, and the atrium behind within the body of the houſe, which is directly contrary to the deſcription.

under fide of the beams, is as much as their length, wanting a fourth part: the remainder[2*] is given to the lacunaria and arcæ above the beams.

The breadth of the alæ on the right and left, if the length of the atrium be from thirty to forty feet, is made a third part thereof: if the length be from forty to fifty feet, it is divided into three parts and a half, of which one part is given to the alæ; if the length be from fifty to fixty feet, the alæ have a fourth part of the length; if from fixty to eighty, the length is divided into four parts and a half, of which one part makes the breadth of the alæ; if from eighty to a hundred feet, the fifth part of the length exactly conftitutes the breadth of the alæ: their lintel beams are placed fo high that the heights may be equal to the breadths.[3*]

(2*) What is to be underftood by the word *reliquum* is a little doubtful: by the fentence preceding it feems moft naturally to point to the remainder of the length of the atrium when three fourths is deducted therefrom; and yet one fourth of the length of the atrium feems to be too great an allowance for the lacunariæ and arcæ, if by thofe words the entablature be underftood.

The lacunaria very probably means the entablature, but the arcæ, which in the foregoing chapter is mentioned in fpeaking of the gutters, and generally fignifies fome kind of fence, may very likely allude to a plutæum or fence (like our baluftrades or parapets) on the top of the cornice; on this fuppofition, one fourth of the length may be a very reconcileable proportion.

Galiani fuppofes that as Vitruvius hereafter prefcribes (as a general rule for all apartments) that their height fhould be equal to half the united fum of their length and breadth, the word *reliquum* alludes to the remainder of that proportional height when three fourths of the length of the atrium is deducted therefrom; but then he has underftood the words *lacunariorum & arcæ* to mean the parts between the tops of the columns, and the ceiling of the alæ: which idea the following note will contribute to difprove.

(3*) Vitruvius does not explain whether the breadth allowed to the alæ is to be given to each, or divided between both, nor whether the alæ were included or excluded from the proportional meafure of the atrium before affigned. Both which, as well as the fentence concerning the height of the lintel beams of the alæ, have been differently underftood by the commentators.

Barbaro and Palladio have believed that the proportion allowed to the alæ fhould be divided between both, and that the alæ fhould be excluded from the beforementioned proportion of the atrium. Perrault and Galiani have agreed with them in the former, but differed in the latter point, underftanding that the alæ are to be included in the proportional meafure of the atrium. Barbaro indeed feems to have been in doubt concerning the former point, having made dotted lines to fhew that the whole meafure allowed might be given to the breadth of each alæ. Thefe points will be determined by the following queftion concerning the height of the lintel beams.

"Trabes earum liminares ita alte ponantur ut altitudines latitudinibus fint æquales." "Their lintel beams are placed fo high, that the heights may be equal to the breadths." Thefe words feem to allude to the height of the lintel beams of the alæ, of whofe proportions Vitruvius is here treating, and the breadth here mentioned feems alfo to mean the breadth of the alæ (making, according to his ufual method, the height and breadth equal); for in fpeaking of the atrium before, and of the tablinum afterwards, he gives their refpective heights at the places where he treats of their other proportions; and thofe heights are proportioned to their own meafures, either of length or breadth: it therefore appears moft probable that Vitruvius follows the fame method in treating of the alæ, and that confequently the heights and breadths here mentioned allude to the alæ only: yet this has been otherwife underftood. Barbaro and Palladio underftand the height here mentioned to be that of the alæ, but conceive the breadth to mean that of the whole atrium; and to reconcile this with the height before allowed to the atrium, they imagine the one to mean the height to the under part of the beams or entablature, and the other to the upper part; although

it is clearly expreſſed, that the under part is meant in both caſes. This is more extraordinary in them, who conceive the atrium to be the ſame as the cavædium, where the columns are expreſsly ſaid to be placed under the beams; plainly indicating that, by the beams, Vitruvius means thoſe timbers which lie immediately over the heads of the columns.

Galiani agrees with Barbaro and Palladio in underſtanding the breadth mentioned, to mean that of the whole atrium; but he ſuppoſes the height alſo to mean that of the atrium, and not, as they do, of the alæ; although the height of the atrium has been before aſcertained: and to reconcile this with the height before allowed to the atrium, he underſtands this latter to allude only to atriums of eighty feet long and upward, becauſe that is the length mentioned by Vitruvius immediately before he ſpeaks of this latter height. But this is far from being ſatisfactory; it might with equal reaſon be ſuppoſed that where the height of the tablinum or atrium is mentioned, it alludes only to tablinums or atriums of the dimenſions immediately preceding; the words ſo interpreted occur in deſcribing the alæ, they are *trabes earum liminares, their lintel beams*; theſe muſt mean the lintel beams of the things in deſcription (i. e. the alæ), and cannot mean thoſe of the atrium, becauſe *earum* being plural ſignifies the lintel beams of two or more things. There is the ſame reaſon alſo, for ſuppoſing the word *latitudinibus* alludes to the breadth of the alæ, for it ſhould have been in the ſingular, if it had meant that of the atrium; and it would have been more like Vitruvius's manner to have added the word *atrii* after it, as he does in deſcribing the tablinum, and farther on in ſpeaking of the impluvium: *Impluvii lumen latum latitudinis atrii.* Indeed it would have been neceſſary ſo to have done, to ſhew that he did not ſpeak of the thing under deſcription; and the omiſſion of it is a ſtrong implication that it does not mean the breadth of the atrium, or of any thing but the ſubject in deſcription, viz. the alæ.

If theſe arguments be admitted to be juſt, then the other doubtful points will be hereby determined; for if the height of the alæ be no more than equal to their own breadth, it will neceſſarily follow, that the proportion aſſigned muſt be given to the breadth of each alæ, and muſt not be divided between the two, for if it were, the height of the alæ in ſmall atriums would be but five feet, which cannot be ſuppoſed.

If then each ala has in breadth the proportion aſſigned, they muſt be excluded from the proportional meaſure before given to the atrium; for ſhould they be included, they would occupy almoſt the whole breadth of the atrium, and meet in the middle. Even upon the ſuppoſition that the breadth aſſigned were divided between the two alæ, they would occupy ſo much of the atrium as to leave but a narrow ſpace in the middle, and that directly under the lumen or opening in the roof; or if to make the ſpace in the middle larger, the columns were placed within the ſpace allowed to the alæ, thoſe columns being proportioned according to their great height, would occupy ſo much of the breadth of the alæ as to leave but a very narrow and incommodious paſſage between them and the wall; as may be found upon trial of a plan according to the proportions mentioned. In either caſe the columns would engroſs ſo much as to render the apartment very unlike the idea authors give of the atrium; a ſpacious hall where great numbers of people ſometimes aſſembled, and where the buſineſs of juſtice and the ſtate was oftentimes tranſacted.

The example given by Galiani in his plate XXII. is not drawn according to the proportions preſcribed, particularly in the heights.

Barbaro alſo has not obſerved the proportions; as for Perrault's examples, being in perſpective, their proportions cannot eaſily be judged of.

It is certainly difficult to conceive any form for the atrium that will agree with the deſcription, the implication of the context, and the ſtyle of the antique architecture: if the height of the alæ be no more than equal to their own breadth, their height muſt be much leſs than that of the atrium, the latter being three fourths of the atrium's length, and the former only a third, fourth, or fifth of the ſame; ſo that if the alæ were ſeparated from the atrium by a range of columns ſupporting the beams of the atrium, the queſtion ariſes, how the part between the beams of the alæ and thoſe of the atrium was finiſhed? It could not be left open to the air, becauſe the opening for air and light is deſcribed to be in the ceiling of the atrium, and a double floor in the alæ is neither mentioned nor implied by the text; alſo how the beams of the alæ, on the ſide next the atrium, were ſupported, is not aſcertained; for there are no paraſtæ mentioned, as in the Baſilica of Fano, deſcribed in the fifth book: it cannot be ſuppoſed that their ends laid in the columns, for that would be contrary to the practice of the antients; nor can the idea of having columns no higher than the beams of the alæ ſupporting a ſolid wall from thence to the top of the atrium be approved.

From the foregoing arguments it ſeems that the atrium muſt be of a very different form to that uſually repreſented; the whole was probably one large apartment, undivided by columns, and the alæ entirely without it; but whether ſeparated therefrom by a wall, or open by columns or arches, or how connected with the atrium, we are left entirely uninformed.

That columns were ſometimes uſed in atriums, although we know not how or in what part they were diſpoſed, we may learn from the words of Pliny, book 36, chap. 2,

If the breadth of the atrium be twenty feet, deducting a third part, the remainder is given to the ſpace of the tablinum[4*]: if from thirty to forty feet, half the breadth of the atrium is allowed to the tablinum: if from forty to ſixty, the breadth is divided into five parts, and two parts are given to the tablinum; for in ſmaller atriums the ſymmetry muſt not be the ſame as in larger: ſhould the ſymmetry of the greater be uſed in the leſſer, neither the tablinum nor the alæ could be convenient; and if that of the leſſer were uſed in the greater, the members would be huge and enormous. Wherefore I have thought it proper to deſcribe exactly their reſpective proportions, regarding both their utility and appearance.

The height of the beams of the tablinum is an eighth part more than the breadth; to its lacunariæ, it is a third part of the breadth added to that height. The fauces[5*], in leſſer atriums, are a third part, in greater, a half *leſs than the breadth of the tablinum*: the height that the images, with their ornaments, are to be placed, muſt be according to the breadth of the alæ.

Concerning the proportion of the breadth to the height of the portals, if Doric, they

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where, after ſaying 360 columns had been brought to Rome by M. Scaurus, the edile, for the ſcene of a temporary theatre, he adds, "etiamne tacuerunt maximas earum, "atque adeo duodequadragenum pedum Luculleì marmoris, in atrio Scauri collocari"—"the largeſt of them, "thirty-eight feet long, of Luculleian marble, were "placed in the atrium of Scaurus:" and chap. 3d, after expreſſing his opinion that the ſucceeding age will diſapprove of ſuch luxury, he ſays, "quis enim tantarum hodie "columnarum atrium habet?"—"for who at this day "has an atrium with ſuch columns?" At the 1ſt chap. of the 17th book, ſpeaking of L. Craſſus, Pliny adds, "columnas quatuor Hymetti marmoris, ædilitatis gratia "ad ſcenam ornandum advectus, in atrio ejus domus ſteterat, cum in publico nondum eſſent ullæ marmoreæ; "tam recens eſt opulentia"—"four columns of Hymettian marble, which he brought when edile to adorn a "ſcene, he fixed in the atrium of his houſe, at a time "when marble ones had never before been uſed in public; "ſo recent is luxury:" and at the 3d chapter of the 36th book, he ſays, "theſe columns were each but twelve "feet long." Theſe quotations, although they do not inform us how or in what manner columns were introduced in atriums, yet ſufficiently prove, that it could not be in the manner hitherto generally ſuppoſed, i. e. arranged on each ſide, and being as high as the beams of the atrium; for the ſmalleſt atrium Vitruvius deſcribes is not ſo low as twelve feet, and the largeſt is much higher than thirty-eight feet, which was the height of the greateſt columns that ever had been uſed in any private atrium at Pliny's time. Indeed the atriums of Scaurus and Craſſus, we muſt underſtand, were built before the columns were placed therein, ſo that the columns could not be uſed to ſupport the beams of the atriums on each ſide the lumen, as generally repreſented. It is therefore moſt probable that the columns of atriums, when any were introduced, were diſpoſed variouſly according as circumſtances would admit or might require, or as the genius of the architect might ſuggeſt. I have accordingly made uſe of ſuch liberty myſelf in the examples Fig. LVII. and LVIII.

(4*) The tablinum is thought to have been a place appropriated for the preſervation of the family records. Pliny, l. 35. c. 2. ſays, "tablina codicibus implebantur & "monumentis rerum in magiſtratu geſtarum." We are not told whether it be the breadth or length of the tablinum which is here ſpoken of; it is generally underſtood to be the breadth, and the following words, "altitudo "tablini ad trabem adjecta latitudinis octava conſtituatur, &c."—"the height to the beams of the tablinum "is an eighth part more than the breadth," where the breadth only of the tablinum is referred to, tend to corroborate that opinion.

(5*) The fauces are ſuppoſed to be the aperture or door-way between the atrium and tablinum. See Fig. LVII.

are formed in the Doric mode, if Ionic, in the Ionic mode, as explained in the defcription of portals in the fourth book. The breadth of the light of the impluvium[6*] is left not lefs than the fourth, nor more than the third part of the breadth of the atrium; the length is fuch as the proportion of the atrium may occafion.

The periftylium[7*] is, tranfverfely, a third part longer than it is inwardly: the columns are as high as the porticus is broad; the intercolumns of the periftyle are not lefs than three, nor more than four times the thicknefs of the columns: but if the columns of the periftyle fhall be in the Doric mode, modules muft be ufed, as mentioned in the defcription of the Doric mode at the fourth book, that by thofe modules the diftribution of the triglyphs may be properly adjufted.

C H A P T E R V.

Of the Triclinium, Œcus, Exedra, and Pinacotheca.

WHATEVER the breadth of a triclinium[1*] may be, twice fo much fhould be the length. The height of all rooms that are oblong fhould be thus regulated: the meafures of the length and breadth are to be united, and the half of that fum, whatever it may be, is to be

(6*) The impluvium, from this paffage, and from the words of Varro (quoted in the 3d note of chap. 3, of this book), we may conclude was the opening in the ceiling or roof of the atrium, through which the light was admitted. Nardini, page 136, and fome other authors, have fuppofed it was the court-yard itfelf.

(7*) The periftylium was a large area furrounded by a columnade, as we learn from the 11th chap. of the 5th book. Galiani adds, that the mafter's apartments were difpofed around it; and he has in his plan fo difpofed them: but in the third chapter foregoing it is faid that the tricliniums (which were the mafter's apartments) received their light from the cavædium, and confequently they muft fometimes at leaft have been difpofed around the cavædium.

(1*) The triclinium or triclinia (as at the 8th chap. following) was the dining room; the word is fometimes ufed for the dining table, and furrounding couches on which they lay to eat (fee chap. 6). The term is faid to have arifen from there being ufually three couches on the three fides of the table, the fourth fide being left for the attendance of the fervants.

given to the height. But when exedræ or œci[2*] are square, once and half their breadth determines their height. The pinacotheca[3*] as well as the exedra should be made of an ample magnitude; the Corinthian œcus, the tetrastyle, and those which are called Ægyptian[4*], have, with regard to their length and breadth, the same symmetry as the triclinium above mentioned, but on account of the introduction of columns, they are built more spacious. Between the Corinthian and Ægyptian there is this difference; the Corinthian have columns placed either on the podium or on the floor, and above have an epistylium and cornice, either of inside work (wood) or plaster; also above the cornice is a curved ceiling formed elliptically, but in the Ægyptian, upon the epistylium of the columns, and from the epistylium to the walls which are around, is laid an unsheltered floor which is boarded and paved, and surrounds the whole; then upon the epistylium, and perpendicularly over the inferior columns, other columns, a fourth part less than the former, are disposed, upon which is an epistylium and cornice, enriched with lacunariæ; and between these upper columns windows are placed, so that they resemble basilicas more than Corinthian tricliniums.

(2*) The exedræ, from what Vitruvius says of them in the 11th chapter of the 5th book, seem to be rooms for conversation or disputation, and were surrounded with seats; some think they were apartments for study, others, for sleeping in at noon, during the heat of summer. In the 9th chapter of the 7th book they are mentioned as being open places like peristyliums, and perhaps in some cases were so, having a range of columns on one side, by which they were separated from the area.

The œci are explained by Vitruvius in this and in the 6th and 10th chapters following.

(3*) Picture rooms.

(4*) Barbaro believes that the Corinthian and tetrastyle œci were the same, and Galiani thinks the tetrastyle and Egyptian were the same. Vitruvius mentions them thus: œci Corinthii vocantur, &c. Perrault supposes all the œci to have been distinct apartments, which is also my opinion; for although the words above quoted will bear one interpretation as well as the other, yet we may draw some arguments from the context, that may help to decide the question.

The tetrastyle œci we may, from the import of the word, conclude had but four columns; but the Corinthian as well as the Egyptian must have had a range of columns around; for it is said, the Egyptian were more like basilicas than tricliniums; and that the difference between the Egyptian and Corinthian œcus consisted only in the former having a double order of columns, and the other but one single order.

Vitruvius does not mention the difference between either of them and the tetrastyle, because it may be supposed he thought it not likely to be mistaken, the very name of it determining the construction of it, so far as to signify it had but four columns. The tetrastyle and Corinthian cavædiums are also distinguished from each other by this difference in the third chapter foregoing.

From the words, " sed propter columnarum interpositiones"—"but on account of the introduction of columns," we may conclude that in common tricliniums columns were not introduced.

C H A P T E R VI.

Of the Greek Œcus.

Fig. LVII. and LVIII. THERE are ſome œci not made in the Italian manner; theſe the Greeks call *cyzicenous.* They are ſituated toward the north, generally have a view of the garden, and have valved doors in the middle. They are of ſuch a length and breadth that two triclinia[1*], with their ſurrounding appendages, may be placed oppoſite to each other; they have alſo valved windows on the right and left, that the garden may be ſeen through the ſpace of the windows; their height is equal to once and a half their breadth.

In all theſe kinds of apartments ſuch ſymmetry is to be uſed as may render them convenient; and if not obſcured by high walls, they may eaſily be made light; but if they be incommoded by narrowneſs, or other impediments, then ingenuity and judgment will be requiſite to make ſuch deductions from, and additions to, the ſymmetry, as will produce a pleaſing effect, not diſtinguiſhable from that of the true ſymmetry.

C H A P T E R VII.

Of the Aſpects to which theſe Kinds of Buildings ſhould be diſpoſed, to render them convenient and healthy.

WE muſt now ſpeak of the poſition of theſe kinds of buildings with regard to their uſe, and the proper points of the heavens to which they ſhould be directed. The winter triclinium and bath ſhould look to the winter weſt, becauſe the afternoon light is there

(1*) Triclinia is here uſed for the dining tables, &c.

useful[1*]; besides that the opposite western sun shining thereon produces heat, and makes that aspect warm in the evening time.

Bed-chambers and libraries should look to the east, for in these the morning light is required; it is also proper, that the books in libraries may not decay, for in those that look to the south and west, they will be damaged by the damps and worms, which the humid winds generate and nourish, infusing a moist vapour that moulds and rots the books.

The spring and autumn triclinium should look to the east; for the windows being then turned from the force of the sun proceeding westward, render those places temperate at the time they are generally used. The summer triclinium should look to the north, because this aspect is not, like the others, rendered hot at the summer solstice; for, being turned from the course of the sun, it remains always cool, and, when used, is salubrious and pleasant. To the same aspect also should be disposed pinacothecæ, as well as embroidering and painting rooms, that the colours used in the works, on account of the equability of the light, may remain unchanged.

CHAPTER VIII.

Of the private and public Apartments of Houses, and of their Construction according to the different Ranks of People.

THESE buildings being disposed to the proper aspects of the heavens, then the distribution of such places in private houses as are appropriated to the use of the master of the house, and those which are common for strangers, must be also considered: for into those that are thus appropriated, no one can enter unless invited; such as the cubiculum, the triclinium, the bath, and others of similar use. The common are those which the people unasked may legally enter; such are the vestibulum, cavædium, peristylium, and

(1*) It was the custom of the antients to make their principal meal toward the decline of day, immediately before which they usually bathed.

those that may answer the same purposes: but to persons of the common rank, the magnificent vestibulum, tablinum, or atrium, are not necessary, because such persons pay their court to those who are courted by others[1*].

People who deal in the produce of the country must have stalls and shops in their vestibules, and cryptæ, horreæ, and apothecæ[2*], in their houses, which should be constructed in such a manner as may best preserve their goods, rather than be elegant. The houses of bankers and public officers should be more commodious and handsome, and made secure from robbers; those of advocates and the learned, elegant and spacious, for the reception of company; but those of the nobles, who bear the honours of magistracy, and decide the affairs of the citizens, should have a princely vestibulum, lofty atrium, and ample peristylium, with groves and extensive ambulatories, erected in a majestic style; besides libraries, pinacothecas, and basilicas, decorated in a manner similar to the magnificence of public buildings; for in these places, both public affairs, and private causes, are oftentimes determined. Houses therefore being thus adapted to the various degrees of people, according to the rules of decor, explained in the first book, will not be liable to censure, and will be convenient and suitable to all purposes. These rules also are applicable, not only to city houses, but likewise to those of the country; except that in those of the city the atrium is usually near the gate, whereas in the country pseudo-urbana[3*], the peristylium is the first, and then the atrium; having a paved porticus around, looking to the palestra and ambulatories.

Fig. LVII. and LVIII.

I have, as well as I have been able, briefly written the rules relative to city houses, as I proposed. I shall now treat of those in the country, how they may be made convenient, and in what manner they should be disposed.

(1*) "Quod hi aliis officia præstant ambiundo quæ ab "aliis ambiuntur."

This passage is allowed to be unintelligibly worded; I have given what seems to me to be the sense of it.

(2*) I have here written the Latin names, because they are used in various senses, and are differently rendered by the moderns; cryptæ very likely here signifies vaults; horreæ, repositories for grain, or wine, &c.; and apothecæ, store-rooms for various purposes.

(3*) See the explanation of pseudo-urbana at note 14, chap. 2, book 1, where it is called urbana only, pseudo (false) being here added, because the part of the villa that was so called was an imitation of a city house, alluded to by the word urbana; and for that reason it was sometimes called pseudo-urbana. See Fig. LIX.

CHAPTER IX.

Of Country Houses, with the Description and Use of their several Parts.

IN the first place the country should be examined with regard to its salubrity, as written in the first book concerning the founding of a city; for in like manner villas are to be established. Their magnitude must be according to the quantity of land and its produce. The courts and their size must be determined by the number of cattle and yokes of oxen to be there employed. In the warmest part of the court the kitchen is to be situated, and adjoining thereto the ox-house, with the stalls turned toward the fire and the eastern sky; for the cattle seeing the light and fire, are thereby rendered smooth-coated: even husbandmen, although ignorant of the nature of aspects, think that cattle should look to no other part of the heavens than to that where the sun rises. The breadth of the ox-house should not be less than ten feet, nor more than fifteen; the length should be so much as to allow no less than seventeen feet to each yoke.

Fig. LIX.

Fig. LX.

The bath also is to be adjoined to the kitchen, for thus the place of bathing will not be far from those of the husbandry occupations. The press-room should be near the kitchen, that it might be convenient for the olive business; and adjoining thereto the wine-cellar, having windows to the north; for, should they be toward any part which may be heated by the sun, the wine in that cellar would be disturbed by the heat, and become vapid. The oil-room is to be so situated as to have its light from the southern and hot aspects; for oil ought not to be congealed, but be attenuated by a gentle heat. The dimensions of these rooms are to be regulated by the quantity of fruit, and the number of the vessels; which, if they be culleariæ[1*], should in the middle occupy four feet. Also, if the press be not worked by screws, but by levers, the press-room should not be less than forty feet long, that the pressers may have sufficient space: the breadth should not be less than sixteen feet, by which means there will be free room to turn, and to dispatch the work: but if there are two presses in the place, it ought to be twenty-four feet broad. The sheep and goat houses are made so large, that not less than four feet and a half, nor more than six feet, may be allowed to each animal.

(1*) A vessel containing 108 gallons, or, according to some, 143 gallons and 3 pints.

The granary ſhould be elevated from the ground, and look to the north or eaſt, for thus the grain will not ſo ſoon be heated, but, being cooled by the air, will endure the longer: the other aſpects generate worms and ſuch vermin as uſually deſtroy the grain.

The ſtable, above all in the villa, ſhould be built in the warmeſt place, and not look toward the fire, for if theſe cattle be ſtalled near the fire, they become rough-coated; nor are thoſe ſtalls unuſeful which are placed out of the kitchen,[2*] in the open air, toward the eaſt; for in the winter time, when the weather is ſerene, the beaſts, being led thither in the morning, may be cleaned while they are taking their food.

The barn, hay-room, meal-room, and mill, are placed without the villa, that it may be more ſecure from the danger of fire.

If the villa is to be built more elegantly, it muſt be conſtructed according to the ſymmetry of city houſes, before deſcribed; but ſo as not to impede its uſe as a villa.

Great care ought to be taken, that all buildings have ſufficient light, which in villas is eaſily obtained; becauſe there are no walls near to obſtruct it. But in the city, either the height of the party-walls,[3*] or the narrowneſs of the ſtreets, may occaſion obſcurity. It may however be thus tried; on the ſide where the light is to be received, let a line be extended from the top of the wall that ſeems to cauſe the obſcurity, to that place to which the light is required; and if, when looking upward along that line, an ample ſpace of the clear ſky may be ſeen, the light to that place will not be obſtructed; but if beams, lintels, or floors, interfere, the upper parts muſt be opened, and thus the light be admitted. The upper rooms are thus to be managed: on whatſoever part of the heavens the proſpect may lie, on that ſide the places of the windows are to be left, for thus the edifice will be beſt enlightened. As in tricliniums and ſuch apartments, the light is highly neceſſary, ſo alſo is it in paſſages, aſcents, and ſtair-caſes, where people carrying burthens frequently meet each other.

(2*) This ſentence ſuggeſts an idea that the term *culina* did not always, and does not here, ſignify that particular apartment which we call the kitchen, for it is not probable that ſtalls for cattle ſhould ever have been placed within ſuch an apartment: it ſeems likely that it ſignifies the farm-yard or court, and alſo the whole pile of buildings relative to the farm, that may have been diſpoſed around it: ſuch a court is mentioned by the writers on the *re ruſtica*, and called *chors culina.*

(3*) *Communium parietum.* Tacitus (Ann. l. 15), ſpeaking of the regulations made after the conflagration in Nero's reign, uſes theſe words to expreſs party walls. Pliny (35. 14) alſo does (I think) the ſame; the intergereni, he mentions afterward, being in my opinion the partition walls within the houſe, ſeparating the different apartments, not thoſe ſeparating houſe from houſe. Vitruvius has before (at book 2, chap. 8), uſed the ſame words. See note 7, book 1, chap. 1.

I have explained as well as I have been able the diftributions of our buildings, that they may not be unknown to thofe who build; I fhall now alfo briefly explain the diftribution of houfes, according to the cuftom of the Greeks, that they alfo may not be unknown.[1*]

CHAPTER X.

Of the Difpofition of the Houfes of the Greeks.

Fig. LXI. THE Greeks ufe no atrium, nor do they build in our manner; but from the gate of entrance they make a paffage (*A*) of no great breadth: on one fide of which is the ftable (*B*), on the other, the porters rooms (*C*), and thefe are directly terminated by the inner gates. This place between the two gates is called by the Greeks *thyroreion.* After that, in entering, is the periftylium (*D*), which periftylium has porticos (1, 2, 3) on three fides. On that fide which looks to the fouth are two antæ (*E*), at an ample diftance from each other, fupporting beams, and fo much as is equal to the diftance between the antæ, wanting a third part, is given to the fpace inwardly; this place (*F*) is called by fome *proftas*, by others *paraftas.* From this place more inwardly the great œci (*G*) are fituated, in which the miftrefs of the family with the work-women refide. On the right and left of the proftas are cubiculæ (*H*), of which one is called *thalamus*, and the other *amphithalamus*; and in the furrounding porticos, the common tricliniums, cubiculams, and family rooms (*I*) are erected. This part of the edifice is called *ginæconitis.*

Adjoining to this is a larger houfe, having a more ample periftylium (*K*), in which are four porticos (4, 5, 6, 7) of equal height, or fometimes the one (7), which looks towards the fouth, has higher columns: and this periftylium, which has one portico higher than the reft,

(1*) In this defcription, Vitruvius has only treated of the apartments and conveniences of the hufbandry part of villas, and not of the mafter's dwelling, called the villa urbana, or pfeudo-urbana, as he expreffes it in the foregoing chapter; and which he fays is to be governed by the fame rules as he has delivered for city houfes, with the exceptions there mentioned. The defcription he gives, however, is not fo definite as to authorife any one particular difpofition, and no other; he only mentions the general afpects and connections of the feveral apartments: every different villa may have differed in its particular diftribution according as the fituation, nature of the ground, or other circumftances, might render proper or neceffary; and the defign, Fig. LIX. and LX. is only offered as one mode of diftribution, conforming to the defcription of Vitruvius and other antient authors as nearly as has occurred to me.

is termed *Rhodian.* In thefe houfes they have elegant veftibulums, magnificent gates, and the porticos of the periftyliums are ornamented with ftucco, plaifter and lacunariæ, of infide work (wood). In the porticos which look to the north are the Cyzicene triclinium (*L*), and pinacothecæ (*M*); to the eaft are the libraries (*N*), to the weft, the exedræ (*O*), and in thofe looking to the fouth are the fquare œci (*P*), fo large, that they may eafily contain four fets of dining couches, with the attendants, and a fpacious place for the ufe of the games. In thefe œci are made the men's dining couches, for it is not their cuftom for the mothers of families to lie down to dine.[1*] This periftylium and part of the houfe is called *andronitides*, becaufe here the men only are invited, without being accompanied by the women.

On the right and left alfo, fmall houfes (*Q*) are erected, having proper gates, tricliniæ, and convenient cubiculæ (*R*), that when ftrangers arrive, they may not enter the periftylium, but be received in this hofpitalium: for when the Greeks were more refined and opulent, they prepared tricliniæ, cubiculæ, and provifions, for ftrangers; the firft day inviting them to dinner, afterwards fending them poultry, eggs, herbs, fruits, and other productions of the country. Hence the pictures reprefenting the fending of gifts to ftrangers are by the painters called *xenia.* Mafters of families, therefore, while they abode in the hofpitium, feemed not to be from home, having the full liberty of retirement in thefe hofpitaliums. Between the periftylium and hofpitalium are paffages (*S*), which are called *mefaulæ*, becaufe they are fituated between two *aulæ*: thefe are by us called *andronas*; but it is remarkable that the Greeks and Latins do not in this agree; for the Greeks give the name of *andronas* to the œcus where the men ufually dine, and which the women do not enter.

It is the fame alfo with fome other words, as *xyftus*, *prothyrum*, *telamones*, and others, for *xyftos* is the Greek appellation of thofe broad porticos, in which the athletæ exercife in winter time; whereas, we call the uncovered ambulatories *xyftos*; and which the Greeks call *peridromidas.* The *veftibula*, which are before the gates, are by the Greeks called *prothyra*; whereas, we call *prothyra* that which the Greeks call *diathyra.* The ftatues of men bearing mutules or cornices we call *telamones*, for what reafon is not to be found in hiftory; but the Greeks call them *Atlantas*; Atlas being in hiftory reprefented as fupporting the world; for he was the firft who, by his ingenuity and diligence, difcovered and taught mankind the courfe of the fun and moon, the rifing and fetting of all the planets, and the revolutions of the heavens;

(1*) The antients had mufic and other entertainments performed before them while at their meals. This cuftom is indicated in feveral antient baffo-relievos, and there are fome in which a woman appears fitting while the man is lying on the dining couch: of the latter kind, one was feen by Mr. Stuart, over the door of a church at Athens, a copy of which I have feen among his fketches.

for which benefit the painters and ſtatuaries repreſented him bearing the whole earth, and the Atlantides his children, which we call *Vergilias*, and the Greeks *Pleiades*, are placed among the ſtars in the heavens. I have not, however, mentioned this in order to change the cuſtomary names or manner of diſcourſing, but only to explain them, that theſe things might not be unknown to the lovers of knowledge.

I have now deſcribed the cuſtomary formation of houſes according to the Italian and Greek manners, with their reſpective ſymmetry and proportions; as therefore I have before written of beauty and decor, I ſhall here treat of the ſtability of edifices, and how they may be made to endure for a long time without decay.

CHAPTER XI.

Of the Stability of Edifices and of their Foundations.

IF edifices, which are built level with the ground, have their foundations conſtructed in the manner we have explained in the foregoing books that treat of walls and theatres, they will without doubt endure to a great age; but if vaults and arches are to be made, the foundations ſhould be thicker than the walls of the ſuperſtructure; and the walls, piers, and columns, ſhould be diſpoſed perpendicularly over the middle of thoſe below them, that they may ſtand firmly; for if walls or columns overhang, they cannot long remain firm. Lintels (liminæ) between piers and antæ, will not be damaged if poſts be ſet under them, for lintels and beams, when overloaded in the middle, occaſion fractures in the building; but when poſts are placed under them, and wedged, the beams cannot ſettle or be damaged. It likewiſe may be ſo ordered that the weight of the walls may be diſcharged by arches of wedges[1*] correſponding to their centers; for if over the beams or heads of the lintels arches be turned, firſtly, the weight being removed, the timbers will not bend, and then if they ſhould be decayed by age, they may, without the trouble of propping, be eaſily changed.

(1*) The ſtones forming an arch are cut in the form of a wedge, whence Vitruvius ſo calls them, and I have choſen to retain his manner of ſpeaking.

In edifices which are built with piers and arches of wedges with the joints tending to their centers, the extreme piers are to be made of a greater breadth, that they may refift the force when the wedges, preffed by the weight of the walls, and impelling toward the center, thruft againft the abutments; for in that cafe, if the angular piers be of a greater breadth, they will, by confining the wedges, give firmnefs to the work: as great attention is to be given to this article, fo likewife is it to be obferved, that all walls ftand perpendicularly, and in no part overhang.

But the greateft care ought to be taken in the foundation, becaufe it is often greatly damaged by the (internal) mafs of earth; for this is not always of the weight it is in fummer. In winter time, by imbibing the rain-water it will be greatly increafed both in weight and fize; and will rupture and extrude the inclofing walls. To prevent this effect, therefore, it muft be thus ordered; firft, the thicknefs of the wall is to be proportioned to the magnitude of the mafs, and then anterides or erifmæ (2*) (*A*) are to be erected in the front fo far apart as is equal to the height of the foundation. Their thicknefs is to be the fame as that of the foundation wall; and their projection at bottom is alfo to be equal to the thicknefs of the fame wall; from thence diminifhing gradually, till at the top they may be as prominent as the thicknefs of the work (3*); moreover, adjoining to the infide of the wall, toward the mafs of ground, teeth (*BB*) formed like thofe of a faw, are to

Fig. LXII.

(2*) Buttreffes or counterforts.

(3*) Both Perrault and Galiani have in this place deviated from the text, the latter without taking any notice of fuch deviation.

They fay, that the anterides or erifmæ fhould at bottom project from the wall as much as the height of the wall, whereas the text clearly expreffes, " quam craffitudo " conftituta fuerit fubftructionis" — " as much as the " thicknefs of the wall." Their reafon for this feems to be, that as Vitruvius adds, " deinde contrahentes gra- " datim ita uti fummam habeant prominentiam quanta " operis eft craffitudo"—" from thence diminifhing gra- " dually, till at the top they are as prominent as the " thicknefs of the work," and underftanding by this, that the projection of the erifmæ at the top is alfo to be equal to the thicknefs of the wall, and to increafe gradually as they approach toward the bottom, they conclude that the text was erroneous in one or other of thofe paffages, accordingly they have fixed on the former, and altered it as above mentioned; although it is clearly and determinately expreffed, leaving the latter paffage (which is indeed vague and doubtful) unaltered: for this latter paffage may be underftood to fignify, that the anterides fhould project at the top of the foundation no more than is fufficient to receive the thicknefs of the work of the fuperftructure with its projecting pilafters, &c. as fhewn in Fig. LXII. by the profile of the anterides *F. G.* In this fenfe Barbaro has underftood it; and that this is the true fenfe, the determinate manner in which the quantity of the projection at bottom and the diminution from thence upward is expreffed, and in which all the copies agree, renders it highly probable.

Perrault remarks, that as Vitruvius affigns the diftance of the anterides to be equal to the height of the wall, the anterides will confequently be fewer as the wall is higher, which ought to be directly the contrary, and fhould be more numerous and clofer in proportion as the wall is higher, as being in that cafe weaker and wanting more fupport; he therefore fuppofes we fhould read *craffitudo* inftead of *altitudo*, and that the diftances fhould be equal to the thicknefs of the wall: but this is taking it for granted that the wall, whether high or low, is to be always of the fame thicknefs; whereas it is always underftood that walls are to be made thicker in proportion as they are higher, and, as Vitruvius before fays, in pro-

be built, each tooth projecting fo far from the wall as is equal to the height of the foundation; the thicknefs of the walls of the teeth being equal to that of the foundation wall. At the extreme angle (*C*) an extent (*CD*) equal to the height of the foundation, is marked off on both fides; from the interior angle, and from thofe marks, a diagonal wall (*DD*) is built; from the middle (*E*) of which, another wall (*EC*) is adjoined to the angle of the wall. Thus the teeth and diagonal walls will not fuffer the weight of the earth to prefs againft the (foundation) wall, but will divide and reftrain the preffure of the mafs.

I have thus explained how works may be executed without defect, and the cautions to be ufed in the beginning; for with regard to the tiles, joifts, or affers, the fame care is not required, becaufe thefe, when defective, are eafily changed. I have alfo explained the means by which thofe things that are adjudged to be not folid may be made firm.

What kind of materials fhould be ufed is not in the power of the architect to determine, becaufe all kinds of materials are not produced in all places, as is obferved in the annexed books; befides it is at the option of the proprietor whether he will build with brick, or rubble, or hewn ftones. All buildings may be confidered in a threefold view; that is, the excellence of the workmanfhip; their magnificence; and the defign (difpofitio): when a work is completed with all poffible magnificence, the coftlinefs is admired; when it is well executed, the fkill of the workmen is approved: but when the beauty refulting from the proportions and fymmetry fhall be commended, it will be to the glory of the Architect; and this is moft likely to happen when he patiently hears advice from the workmen, and even from the ignorant; for all men, and not only architects, may difcover what is right (in a building). But between them and the ignorant there is this difference; the ignorant know not how it will appear till they fee it done; whereas Architects, as foon as it is formed in their minds, and before it is begun, have a conception of its beauty, convenience, and decor.

I have now written as clearly as I am able what I have thought neceffary concerning private buildings, and how they fhould be built: concerning their finifhing, fo that it may be elegant, and endure without defect for a long time, I fhall treat in the following book.

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portion to the greatnefs of the mafs of ground they enclofe. Confidering it in this light therefore, the height and thicknefs of the walls and the diftance of the anterides will be in the fame proportion to each other in all cafes, and of courfe be proportionally firm and ftrong.

Vitruvius leaves it uncertain whether the thicknefs of the teeth and diagonal wall D, at the angles, is excluded or included, in the projection he affigns them, from the main wall. I have determined for the former, as otherwife thofe diagonal walls would not bear againft the anterides, which, as being the ftrongeft part of the wall, they ought to do.

END OF THE SIXTH BOOK.

THE

ARCHITECTURE

OF

M·VITRUVIUS·POLLIO.

BOOK THE SEVENTH.

PROEM.

THE ancients wifely and ufefully by means of their writings delivered their knowledge to pofterity, fo that not being loft, but increafing by the volumes publifhed in every age, the utmoft poffible degree of fcience might in time be attained. Not fmall therefore, but great thanks to them are due, fince they have not with invidious filence fuppreffed, but with care tranfmitted to us by their writings the memory of all kinds of knowledge: had they not done thus, we fhould not know the exploits that happened at Troy; what Thales, Democritus, Anaxagoras, Xenophanes, and other philofophers, have thought of the nature of things; what Socrates, Plato, Ariftoteles, Zeno, Epicurus, and others, have determined concerning the duties of human life; or the actions of Crœfus, Alexander, Darius, and other kings; nor could the means by which they were done be known, unlefs the ancients had by their precepts and commentaries preferved the memory of them to pofterity. As to thefe therefore our thanks are to be given, fo on the contrary thofe who, ftealing from their writings, publifh them for their own, are to be cenfured; and thofe alfo who take not the evident meaning of authors, but invidioufly glory in perverting it, not only deferve reproof, but as living with ill intentions, ought to be condemned to punifhment. It is reported that fuch things were ftrictly avenged by the antients, fome examples of which, as they are tranfmitted to us, it will not be foreign to the purpofe to recite.

The Attalic kings, ſtimulated by their great love for philoſophy, founded, for the benefit of the community, the excellent library of Pergamus. Ptolemy alſo at that time, incited by a great deſire and zeal for literature, with no leſs aſſiduity endeavoured in the ſame manner to eſtabliſh that of Alexandria. But when by the utmoſt exertions he had completed it, he thought it not ſufficient unleſs he could, like the propagation of ſeed, cauſe it to increaſe. For this purpoſe he inſtituted games, dedicated to Apollo and the Muſes, and appointed rewards and honours to the victorious in literature, in the ſame manner as in the games of the athletæ. This ſettled, when the time of the games approached, men of learning were appointed to be judges; the king had, from the city, already ſelected ſix, and not readily finding a ſeventh who was qualified, he applied to thoſe who ſuperintended the library: enquiring if they knew of one who was proper, they replied, there was one Ariſtophanes, who with great attention and aſſiduity came every day to read the books according to their order. At the convention of the games, therefore, when the ſeats of the judges were ſet apart, Ariſtophanes was ſummoned with the reſt, and ſeated in the place deſigned for him.

The firſt brought to the conteſt were the poets; when theſe had recited their verſes, the people unanimouſly ſignified to the judges which they ſhould prefer: when therefore the opinion of each was aſked, ſix of them adjudged the firſt premium to him whom they obſerved had moſt pleaſed the multitude, and the following accordingly; but when the opinion of Ariſtophanes was demanded, he adjudged the firſt prize to him who had leaſt pleaſed the people; this exciting the indignation of the king, and the whole aſſembly, he aroſe, and requeſted leave to ſpeak. Silence being made, he informed them, that this one was the only poet, the reſt had recited the verſes of others; and it behoved the judges not to approve robbers, but authors. While the people were wondering, and the king doubting, he, truſting to his memory, quoted many books from ſundry repoſitories, and comparing them with what had been recited, forced a confeſſion from the plagiariſts themſelves: upon which the king ordered them to be proceeded againſt as robbers, and being condemned to ignominy, diſmiſſed; but he liberally rewarded Ariſtophanes, and appointed him the ſuperintendant of the library.

Some years afterward Zoilus from Macedonia, who aſſumed the ſurname of Homeromaſtix (Homer's ſcourge) came to Alexandria, and repeated before the king his writings againſt the Iliad and the Odyſſey. When Ptolemy perceived that the father of poets, and of philoſophy, and whoſe works are admired by all nations, was, though abſent, reviled and cenſured, filled with anger he gave him no anſwer: Zoilus therefore, after waiting a long time in that kingdom, preſſed by want, ſupplicated the king for ſome gratuity; but it is ſaid, the king replied, Homer, who has been dead more than a thouſand years, has in

every age ſince provided for many thouſands of men; he then who pretends to greater abilities ought to be able to provide not only for himſelf, but alſo for many more. In fine, his death, he being condemned as a parricide, is variouſly related; ſome write that he was crucified by Philadelphus; ſome, that he was ſtoned; and others, that he was burnt alive at Smyrna: but whichever happened, he well deſerved the puniſhment, for no otherwiſe does he merit, who cenſures thoſe who cannot anſwer concerning the ſenſe of what they have written.

I therefore, O Cæſar, in this publication, have neither changed the titles of the books of others and prefixed my own name, nor have I, by cenſuring the opinion of others, endeavoured to applaud myſelf; but pay infinite honour to all authors who, with judgment and ingenuity, have provided for us an abundance of various kinds of knowledge; by which means, like drawing water from ſprings, and conducting it to the intended places, we are enabled to write on ſubjects more copiouſly and expeditiouſly, and, ſupported by ſuch authorities, we may even be enabled to produce new works. I having ſuch aſſiſtance, from thoſe by whom the principles of my ſubject have been prepared, have endeavoured to advance farther.

Agathareus of Athens, at the time Æſchylus taught there, was the firſt who made the tragic ſcene, and left a diſſertation thereon; from this example, Democritus and Anaxagoras wrote on the ſame ſubject, teaching how to project the rays from the point of ſight, fixed at a certain place as the centre, to which the lines naturally tend: thus by uncertain things repreſenting the certain appearances of buildings on the face of the ſcene; and, though deſcribed on a direct plane, ſome appear to recede, and ſome to project. Afterward Silenus publiſhed a volume on the Doric ſymmetry; Theodorus wrote of the Doric temple of Juno at Samos; Cteſphon and Metagenas of the Ionic temple of Diana at Epheſus; Phileos[1*] of the Ionic temple of Minerva at Priene; Jetinus and Carpion of the Doric temple of Minerva in the citadel of Athens; Theodorus Phocæus of the dome at Delphos; Philo of the ſymmetry of ſacred edifices, and of the arſenal at the port of Pyræus; Hermogenes of the Ionic pſeudo-dipteral temple of Diana at Magneſia, and of the monopteral temple of Bacchus

(1*) In the firſt chapter of the firſt book the architect of the temple of Minerva at Priene is called Pythius, wherefore Galiani ſuppoſes one or the other to be a miſtake of the copyiſts: but it is to be obſerved, that Phileos is not here mentioned as the architect, but only as the author of a treatiſe upon that temple; and if it ſhould be admitted that he was alſo the architect, it may have been upon the rebuilding of that temple, which was about the time of Alexander, as the inſcription publiſhed in the Ionian Antiquities, page 15, renders probable, the firſt temple (to which Pythius may have been the architect) having been deſtroyed by Xerxes, among the reſt of the Ionian temples.

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at Teos; Argelius of the Corinthian ſymmetry, and of the Ionic temple of Eſculapius at Tralles, on which it is ſaid he worked with his own hands; Satyrus and Phyteus of the mauſoleum, in which they have been exceedingly fortunate, ſince thoſe whoſe ſkill has been admired in all ages, and gained immortal honour, have contributed their excellent works; for in the ſeveral fronts particular parts were undertaken to be wrought and ornamented by particular artiſts, as Leochares, Bryaxes, Scopax, Praxiteles, and alſo, as ſome think, Timotheus, and their great excellence in their arts has cauſed this work to be accounted one of the ſeven wonders of the world.

Many leſs famous have alſo written precepts upon ſymmetry, as Nexaris, Theocydes, Demophilos, Pollis, Leonides, Silanion, Melampus, Sarnacus and Euphranor; nor have there been fewer writers upon mechanics, as Diades[2*], Architas, Archimedes, Cteſibios, Nymphodorus, Philo Byzantæus, Diphilos, Democles[3*], Charidas, Polyidos, Phyros, and Ageſiſtratos: from whoſe writings I have collected in one body what I thought to be moſt uſeful, and that the rather, as I have obſerved many volumes have been publiſhed on theſe ſubjects by the Greeks, but very few by us; for it is wonderful that Fuſſitius was the firſt among us who publiſhed a book thereon. Terentius Varro alſo, in his treatiſes concerning new ſciences, wrote one on Architecture, and Publius Septimius two; ſince which, to this time, no one has written on the ſubject, although there muſt have been ſome great architects among the antient citizens, who were able to have written judiciouſly, ſince after the architects Antiſtates, Calleſchros, Antimachides, and Porinos, had raiſed the foundation of the temple of Jupiter Olympius, which Piſiſtratus commanded to be built at Athens, and which at his death had been relinquiſhed on account of the troubles of the republic for about two hundred years, when king Antiochus undertook to be at the expence of the work—Coſſutius, a Roman citizen, was then appointed to be the architect; and he, with great judgment and ſcience, determined the dimenſions of the cell, the dipteral diſpoſition of the columns around, and diſpoſed the epiſtylium and other ornaments according to the rules of ſymmetry; and this is no common work, but is equalled by few in magnificence, for but in four places are there temples, enriched with marble work, from which the names of thoſe places derive great celebrity, and of which the excellent and judicious contrivance is admired in the aſſembly of the gods.

(2*) Diades is again mentioned at the 19th chapter of the 10th book. In all the printed editions that I have ſeen, excepting that of Perrault, it is, in this place, written cliades; but in every manuſcript that I have examined I have found it written diades: the difference is ſuppoſed to have ariſen from the copyiſts taking d for cl, or the contrary.

(3*) Democles is omitted in the generality of the printed editions; Galiani ſays in all except that of Jocundus; but the old French edition by Jean Martin alſo has it, and I have ſeen no manuſcript without it; wherefore I have inſerted it, as Galiani alſo has in his edition of the text.

The firſt of theſe is the Ionic temple of Diana of Epheſus, begun by Cteſiphonte the Gnoſion, and his ſon Metagenes, and which afterward Demetrius the prieſt of the ſame Diana, and Peonius the Epheſian, were appointed to complete. Next, the Ionic temple of Apollo at Miletus,[4*] which the ſame Peonius and Daphnis the Mileſian conſtructed. Then, the temple of Ceres and Proſerpine at Eleuſis, in the Doric manner, by Jetinus: the cell of this was of a vaſt magnitude, and had at firſt no exterior columns, to adapt it the better for the performance of the ſacrifices; but afterward, when Demetrius Phalereus governed at Athens, Philon erected columns in the front, thereby making it a proſtyle temple; the veſtibulum being by this means enlarged, allowed more room to the ſacrificers, and added dignity to the edifice. Laſtly, the temple of Jupiter Olympius at Athens, of ample dimenſions, and of the Corinthian ſymmetry and proportions, as before mentioned, the architect of which is ſaid to have been Coſſutius, of whoſe writings none are to be found: nor from Coſſutius only are ſuch writings wanting, but alſo from Caius Mutius, by whoſe great ſkill the cells of the Marian temples of Honour and Virtue, and the ſymmetry of the columns and epiſtylium, deſigned according to the juſt rules of art, were completed. Had this work been built of marble, ſo that it might derive as much grandeur from its coſtlineſs and magnificence as it does of excellence from art, it might be named with the firſt and moſt excellent works.[5*]

It appears then that there were formerly ſome great architects of our own nation, as well as that of the Greeks, and ſeveral even in our memory; yet as they have publiſhed but few precepts, I thought it not proper alſo to remain ſilent, but to explain the different parts of the art in different books: as therefore I have in the ſixth book written of the rules that regard the building of private houſes; in this, which is the ſeventh, I ſhall treat of their finiſhing, and the means by which they may be made beautiful and ſubſtantial.

(4*) This temple, with thoſe of Minerva at Priene, and Bacchus at Teos, mentioned in the former part of this proem, are the three temples, the remains of which have been publiſhed in the Ionian Antiquities, under the auſpices of the ſociety of Dilletanti; by whoſe zeal for the improvement of the fine arts, and at whoſe expence, theſe valuable antiquities have been collected.

(5*) Livy, b. 37. ſays, two ſeparate temples of Honour and Virtue were built by Marcellus, the prieſts not permitting one temple to two divinities. Vitruvius has before mentioned them at b. 3. ch. 1. where, as here, he adjoins the word *Mariana*. Perrault has from this word ſuppoſed the temples to have been built by Marius, but this ſuppoſition has no authority.

Galiani underſtands them to have been ſituated at or near the trophies of Marius, yet theſe trophies are ſuppoſed to have been in the 5th region of Rome, by the Eſquiline hill, and the temples were on the Aventine hill near the gate Capena. See Nardini, page 163. So that there muſt have been ſome other reaſon for uſing the word Mariana that has not come to our knowledge.

Pliny, 35. 10. ſays, theſe temples were rebuilt by Veſpaſian.

CHAPTER I.

Of Pavements.

WE will firſt begin with pavements; which hold the chief place in the finiſhing. The utmoſt care muſt be taken that they may remain ſolid, and if they be laid on the ground, it muſt be examined whether the ſoil is intirely firm, and if ſo, it muſt be levelled, and covered with a rough ſtatumen; but if the whole or part of the ſpot ſhould be of an infirm texture, it muſt with great care be rendered ſolid by piling. In contignations (floors) it muſt be attentively obſerved that no walls be built under the pavement ſo as to touch it, but that they be detached, the boarding being ſuſpended over them; for when it is made ſolid, the contignation drying or ſettling, and the wall remaining immoveable, neceſſarily cauſes fractures on either ſide: it is to be obſerved alſo not to unite planks of the eſculus[1*] with thoſe of the oak; for as ſoon as oak receives any moiſture, it warps, and thereby cauſes fiſſures in the pavement; but if boards of the eſculus be not to be procured, and thoſe of oak are obliged to be uſed, they ſhould be cut very thin, that, having leſs force, they may be more eaſily confined by the nails; then on every joiſt the ſides of the boards are to be fixed by two nails, that the edges may not riſe by their warping in any part: as for the cerrus, fagus or farnus, they cannot endure long. The planking being done, fern, if it can be had, if not, ſtraw is to be ſtrewed over, to defend the wood from the corroſion of the lime, and then the ſtatumen is to be laid, conſiſting of ſtones not leſs than ſuch as will fill the hand: the ſtatumen being done, it is to be covered with the rudus[2*], which if new, three parts thereof is to be mixed with one part of lime, but if from old materials, five parts with

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(1*) I have mentioned this tree, and the cerrus, fagus and farnus, a little below, by the Latin names, on account of the uncertainty of their ſignifications. See chapter 9, book 2.

(2*) The rudus is explained by an anonymous antient author (publiſhed by the marquis Poleni in his Exercitationes Vitruvianæ, p. 198), to conſiſt of larger ſtones pounded and mixed with lime; *rudus eſt majores lapides contuſi cum calce miſti.* The words of the text indicate it to be compoſed of refuſe pieces of ſtones or bricks, &c. which we ſhould call rubble, and which may be either from new materials, or from ſuch as have been uſed in a former building; in which latter caſe Vitruvius directs more lime to be mixed, on account of the matter being drier, and it is then called *rudus redivivum*, being called *rudus novum* in the former caſe.

Perrault (as Galiani has obſerved) has miſtaken the ſtatumen and the rudus to be the ſame thing, which error he has probably been led into by the words *ſtatuminatione facta*, immediately following the deſcription of the *rudus*; but it is evident that Vitruvius inſerts theſe words to ſhew that the ſtatumen, as he has before deſcribed it, is to be laid firſt, and the rudus laid upon it; for he has juſt before mentioned the neceſſity of defending the boards from the lime, and it cannot therefore be ſuppoſed that he would now direct the rudus, which is compoſed of lime, to be laid immediately upon them.

two; then laying it on, it muſt be thoroughly pounded by a number of men with wooden rammers, till it be compact, and the thickneſs be three quarters (of a foot): upon this is laid the nucleus, compoſed of three parts of teſtaceous matter [3*] mixed with one part of lime, ſo that the thickneſs of the pavement may not be leſs than ſix inches. Over the nucleus the paving pieces, whether ſectiliæ or teſſeræ, [4*] are to be exactly laid with rule and level; when theſe are laid, and have a proper declination, they muſt be ſo rubbed, that, if they be ſectiliæ, no riſings may remain, whether they be oval (in ſcutulis), triangular, ſquare, or hexangular, but the whole compoſition muſt be perfectly ſmooth: if they be teſſeræ, all the angles ſhould be equal, and none riſe from the ſurface; for if the angles are not all equal and level, the ſurface will not be ſo ſmooth as it ought: the pointed tiburtine tiles are much deſired, becauſe they have no hollows or protuberances, but are rubbed flat and ſtraight upon the rubbed ſurface; when it is to be levigated and poliſhed, marble powder is ſifted, and over that is laid a coat of lime and ſand.

(3*) The word *teſta* in the text may ſignify the matter of any burnt clays, as bricks, tiles, &c.: it is ſo uſed by Vitruvius in ſeveral other paſſages, as *teſtaceum pavimentum,* in chapter 4. following.

Perrault has erroneouſly written *two* parts of this teſta is to be uſed to one part of lime, whereas the text expreſſes three parts to one.

(4*) L. 7. ch. 1. *ſive ſectilibus, ſeu teſſeris—whether ſectiliæ or teſſeræ.*—Of theſe two kinds of pavements Perrault and Galiani agree that the teſſeræ is the Moſaic kind, formed by very ſmall cubical pieces, becauſe teſſeræ was one name uſually given to the ſmall cubical bodies called dice. Philander on the contrary thinks the ſectiliæ were the Moſaic pavements, to which opinion I alſo incline; for although the word teſſeræ was uſed as one of the names of dice, yet it alſo ſignified a ſquare, or any ſquare body, and may therefore have ſignified a ſquare paving ſtone, either large or ſmall, a cube appearing a ſquare when laid in the pavement; but it probably ſignified a large ſort of ſtone, for the following reaſons. Vitruvius in this chapter ſays, that in the teſſeræ pavements it is neceſſary to work all the angles of the ſtones exactly equal or alike—*ſi teſſeris ſtructum erit ut ex omnes angulos habeant equales,* which is indeed neceſſary in large ſtones, in order that they may be regularly laid, but not in the minute pieces of which the Moſaic pavements conſiſted; becauſe their own figure was not intended to be conſpicuous, they being only uſed as the conſtituent particles of other forms; and the examples of the antient Moſaic that have come to our knowledge prove that ſuch exactneſs was not practiſed in thoſe minute pieces. Again, Vitruvius hereafter mentions *large teſſeræ two inches in thickneſs,* which plainly proves that teſſeræ ſometimes at leaſt ſignified large ſtones; for ſtones muſt be conſiderably large to require to be two inches in thickneſs. Vitruvius directs the ſectilia pavements to be rubbed ſmooth after they are laid, but he does not direct the teſſeræ to be ſo rubbed, which is an implication that theſe latter were large ſtones, that might be ſo previouſly wrought and laid as not to require rubbing afterward; but it would be very difficult or ſcarce poſſible to lay the very minute pieces of the Moſaic pavements in a ſenſibly perfect plane, and therefore they would require rubbing after they were laid.

The example Vitruvius mentions of the tiburtine tiles (which, by their being deſcribed to have no hollows or protuberances, we may infer were not very ſmall) following immediately after the mention of the teſſeræ, is a farther ſupport to the opinion that the latter likewiſe were not of the ſmall kind; large teſſeræ two inches on the edge are alſo hereafter mentioned: this at leaſt proves that all of the teſſeræ kind could not be ſo ſmall as the ſtones uſed in the Moſaic pavements, which were ſometimes leſs than half an inch, and ſeldom more than one inch cube; but as theſe are ſaid to be two inches thick, it implies that their ſurface was much larger: for theſe reaſons, therefore, I am of opinion that the ſectiliæ were the kind now commonly known by the term Moſaic, or rather Muſaic, as Vitruvius writes the word.

But pavements that are expofed to the weather are to be made particularly fubftantial, becaufe the motion of the flooring either fwelling with humidity, fhrinking with drynefs, or fwagging in the middle, is apt to injure the pavement; the ice and froft alfo prevent its remaining entire: if therefore it be neceffary that it fhould by no means be damaged, it muft be thus ordered; when the planking is done, other planks muft be laid thereon tranfverfely, and faftened with nails, forming a double covering to the contignation; then with new rudus a third part of pounded brick is mixed, and to that two parts out of five of lime make the mortar of a proper confiftence. The ftatumen being done, this rudus is laid and thoroughly pounded, fo that it may not be lefs than a foot in thicknefs, and then the nucleus is fpread as before mentioned: the pavement is to be formed of large tefferæ, about two inches on the edge, the declination being two inches in ten feet, and thus, if well tempered and rubbed flat, it will remain free from all defects; but in order that the matter between the joints may not be damaged by the froft, it fhould be faturated every year, before winter, with dregs of oil, which will prevent its imbibing the froft. If it is to be done yet more carefully, two feet tiles, jointed together, muft be laid upon the rudus, having little channels of a finger's breadth cut in the fronts of the feveral joints, which joints being filled with lime tempered with oil, are compreffed and rubbed together; by this means the lime, which remains in the channel, growing hard, fuffers no water nor any thing elfe to penetrate the joints: this being done, the nucleus is laid thereon and beaten with fticks, and over that either large tefferæ or the pointed tiles are laid in the declination before mentioned, and when it is thus done it will not foon decay.

CHAPTER II.

Of the Preparation of the Lime for the Plaſtering and the Stucco.

THE conſideration of the pavements being finiſhed, then the plaſter[1*] is to be attended to. This will be good, if the lime-ſtones be of the beſt kind and ſlaked a long time before they are uſed, ſo that if ſome of the ſtones ſhould be too little burnt in the furnace, by being long macerated in water, they may be diſſolved, and the whole reduced to one conſiſtence; for ſhould the lime be not thoroughly ſlaked, but be uſed freſh, the concealed crude particles it may contain will, when it is laid, occaſion it to emit puſtules, becauſe theſe particles ſlaking when in the work, diſſolve, and deſtroy the ſmoothneſs of the ſtucco.

To know when it is ſufficiently macerated and properly prepared for the work, the lime is to be chopped with an ax in the manner timber is hewn: if the ax meets with lumps, it is not well tempered; and if the iron comes out dry and clean, it ſhews the lime to be periſhing and weak; for when it is fat and well macerated, it will adhere to the iron like glue, and this will be a proof that it is well tempered; then the machines being prepared, the ceilings of the apartments are to be plaſtered, unleſs they are intended to be ornamented with lacunariæ.

(1*) Some ſuppoſe the albaria, which I have rendered plaſtering, to be a ſort compoſed of pure lime, while others think it to be nothing more than a white waſh: that it is a kind of plaſter is evident, for at the 2d chapter of the fifth book, Vitruvius ſpeaks of it as the ſubſtance with which they make cornices.

Perrault thinks albaria means the ſtucco, and that tectoria is the name of the plaſtering in general. Galiani ſuppoſed albaria to ſignify all kinds of plaſtering and wall whiting whatever, and that tectoria is a name including every ſort of incruſtation wherewith the walls may be overlaid. But at the 6th chapter following the word *tectoria* is applied to that ſort of plaſter wherein powder of marble was uſed, and which therefore can be reckoned no other than ſtucco; and as Vitruvius makes a diſtinction between the two, ſaying, at chap. 10. book 5. *albaria ſive tectoria*, it is evident that the albaria cannot be ſtucco alſo: beſides, it is not to be doubted but that in this chapter Vitruvius ſpeaks of the preparation of the lime as proper for all the kinds of plaſtering, not for the ſtucco only; and he here uſes the word *albariis* at the beginning to expreſs his intention, *cum a pavimentorum cura diſceſſum fuerit, tunc de albariis operibus eſt explicandum.* I have therefore generally accepted albaria for the plaſtering of all kinds, and tectoria for the ſtucco only, except in ſome caſes, where the ſenſe was plainly different.

CHAPTER III.

Of the Conſtruction of arched Ceilings, and of the Plaſtering and Stucco Work.

WHEN arched ceilings are required, they may thus be made; parallel aſſers are diſpoſed not more than two feet diſtant from each other, and chiefly on cypreſs wood, becauſe fir is ſoon decayed by worms and age. When theſe aſſers are ſuited to the form of the curve, they muſt be faſtened to the ties fixed to the flooring or roof with nails of iron, and theſe ties ſhould be prepared from ſuch wood as neither worms, age, nor damps can hurt, ſuch as box, juniper, olive, robor, cypreſs, and ſuch kinds; the oak muſt be excepted, becauſe it warps, and cauſes cracks in the work wherein it is uſed: the aſſers being thus fixed, Greek reeds bruiſed are to be tied to them with cords of Spaniſh broom, according as the form may require; alſo upon the upper ſide of the arch a mixture of lime and ſand is to be laid, that in caſe any water ſhould fall thereon from the floor or roof, it may be abſorbed. But if Greek reeds ſhould be ſcarce, thoſe ſlender ones of the lakes are to be united and bound together with cords, as before written, and ſecured with wooden pegs; all the reſt is to be done as above written.

The arches being formed and connected, their under ſurface is to be rough plaſtered[1*], then made even with arenatum[2*], and afterward ſmoothened with chalk or marble (plaſter): when the arches are finiſhed, cornices are wrought under them, which ſhould be made as ſlender and light as poſſible, for when they are large, being loaded with their own weight, they cannot ſupport themſelves; in theſe gypſum[3*] ſhould not be mixed, but the refuſe of marble

(1*) This firſt rough coat of plaſter is called by Vitruvius *trulliſatio*, from *trulla*, trowel, the tool wherewith it was laid: we are not here informed of its compoſition, but in the following chapter we have the words *pro arenato teſta trulliſetur*, and again *teſta trulliſetur*, which encourage an opinion that it conſiſted of lime mixed with pounded tiles or bricks.

(2*) The *arenatum* was from *arena*, ſand, it being a mortar compoſed of ſand mixed with lime; ſo the mortar wherein the powder of marble was uſed was, for the ſame reaſon, called *marmoratum*, though ſometimes granum.

(3*) Gypſum is explained by Pliny, b. 36. ch. 24. He ſays it is a kind of lime, made by burning a ſtone ſimilar to alabaſter, but the beſt is made from talc: in ſome countries it is dug out of the earth ready made by Nature. And he obſerves, that when it is wetted it muſt be uſed directly, as it then quickly becomes dry and hard. From this deſcription it appears plainly that the gypſum of the antients was that kind of plaſter which we now call *plaſter of Paris*, and the Italians *geſſo*.

reduced to a fine powder, which not drying ſo precipitately, admits the whole work to dry equally; the manner of thoſe of the antients is to be avoided, becauſe the great weight of the impending ſofites of theſe cornices renders them dangerous.

Some cornices are plain, and ſome enriched; in apartments where fire or many lights are uſed they ſhould be plain, that they may be more eaſily cleaned. In ſummer rooms and exedræ, wherein there is no ſmoke or ſoot that can hurt, there they may be enriched; for plaſtering, on account of its ſuperior whiteneſs, is eaſily ſoiled with the ſmoke ariſing not only from the building that contains it, but alſo from the adjacent houſes.

The cornices being finiſhed, the walls are to be roughly plaſtered, and thereon, while drying, the arenatum is to be laid, being regulated in length by the rule and line, in height by the perpendicular, and the angles by the ſquare; for thus the regularity of the ſtucco will improve the appearance of the pictures: again, while drying, a third coat is laid, for the more ſubſtantial the arenatum is, the more durable and ſolid will be the ſtucco. When not leſs than three coats of arenatum, excluſive of the trulliſatio (rough plaſter), are laid, then the coat of plaſter in which marble powder is mixed is to be laid; this is to be ſo tempered, that when worked it may not adhere to the tool, but leave the iron clean and free from mortar. When this is done and is dried, it is to be covered with another thinner coat, which, after being well worked and rubbed, is overlaid with one yet more thin: thus the walls being ſecured with three coats of arenatum as well as with the marmoratum, neither fiſſures nor other defects can happen; but the plaſtering, rendered ſolid by beating with ſtaves, and well levigated with white marble (powder), the colours laid thereon will appear bright and ſplendid.

Colours when carefully laid on the ſtucco, while wet, will not fade, but will always remain the ſame, becauſe the lime being deprived of its humidity in the furnace, and made porous and dry, eagerly imbibes whatever moiſture happens to touch it, and by their different properties, the particles or principles uniting together in the mixture, grow into one ſolid body on whatever part applied, and when dry are found to be ſo incorporated as to appear like one ſubſtance, and to have the ſame qualities: the ſtucco, therefore, when properly done, will neither by age become ſcaly, nor will it when cleaned diſcharge the colours, unleſs they have been laid with too little care, or after the work was dry: if then the incruſtation of the walls be done as before written, it will retain its firmneſs and ſplendour to a great age; but if one coat only of arenatum and one thin coat of marmoratum be laid, not having ſufficient ſtrength on account of its thinneſs, it eaſily cracks, nor will it retain its proper ſmoothneſs. A ſilver mirror when formed of a thin plate has but an uncertain and weak reflection; but

when it is of a ſufficient ſubſtance, it receives a ſtrong poliſh, has a ſhining appearance, and reflects images exactly and diſtinctly: and ſo the ſtucco, when of thin ſubſtance, not only cracks, but alſo ſoon decays; but if rendered ſufficiently ſubſtantial by having a proper thickneſs of arenatum and marmoratum, it will, when poliſhed, appear brilliant, and diſtinctly repreſent the figures delineated thereon.

The Greek plaſterers not only uſe theſe means to make their work ſubſtantial, but alſo put the lime and ſand mingled together into a pit, where the matter is pounded by a company of men with wooden rammers; when thoroughly tempered, it is then uſed: ſlabs thereof cut from the antient walls are uſed for abaci, and the ſame kind of ſtucco is uſed in the prominent diviſions around the abaci and mirrors.[4*] If the ſtucco is to be laid on wooden partitions, the perpendicular and tranſverſe pieces of which cauſe cracks, becauſe when they are covered with the mortar they abſorb moiſture, and then ſhrinking as they dry, occaſion fiſſures in the ſtucco; that this may not happen, the following method muſt be obſerved: After the whole wall has been plaſtered, reeds placed cloſe together are to be fixed on the

(4*) "Itaque veteribus parietibus nonnulli cruſtas excidentes pro abacis utuntur, ipſaque tectoria abacorum & ſpeculorum diviſionibus, circa ſe prominentes habent expreſſiones." If it is uncertain what is preciſely meant by the term abaci in the 3d book, it is particularly applied to the flat ſtones that lay upon the tops of the capitals; but its general ſignification is any flat tabulated ſubſtance. Barbaro thinks it here ſignifies tablets for painting on, and Perrault renders it tables. Galiani ſuppoſes it to ſignify bricks, and tranſlates the paſſage to this effect: "Some cut from the old walls pieces of plaſter and uſe them for bricks, and in the ſame plaſtering diſtribute theſe bricks ſo that they form a relievo around the ground of the quadratures."

Though I cannot pretend to aſcertain what Vitruvius here means by the abaci, I cannot be of Galiani's opinion that they are bricks; no inſtance of plaſter being uſed for bricks by the antients has ever been known, or at leaſt come to my knowledge; and it would be very improper to be ſo uſed: it ſeems to me more likely to allude to the pannels into which the ſtucco of the walls might be divided, examples of which are ſeen in ſundry remains of antiquity; the rather alſo on account of theſe abaci being mentioned with the ſpeculi or mirrors, which are tabular ſubſtances ſimilar to ſuch pannels: and the next chapter mentions ſuch abaci being uſed to decorate the walls above the part of the podium or dado as we call it. What Galiani means by *riquadriture*, which I have rendered quadratures, I know not; he has uſed it for ſpeculorum in the Latin, which probably were the ſilver mirrors Vitruvius has before mentioned in this chapter. Galiani may mean the ſame by this word; for if he ſhould mean thereby the abaci, he muſt have uſed that word twice in the ſame ſentence for different meanings.

But the uſing theſe pieces of old plaſter to make the margins or frames around ſuch quadratures (whichever may be meant), as Galiani has tranſlated it, is highly improbable, nor does it appear to me that the Latin words have any ſuch meaning. It would be a very laborious work to cut old pieces of plaſter to make frames; it would be a much more eaſy and more ſubſtantial work to make ſuch frames or mouldings with new plaſter, though it ſhould be neceſſary to be at the pains of making the plaſter for ſuch purpoſes as good as the Greeks made it; and this is indeed my conception of the paſſage, the words *ipſaque tectoria* not, in my opinion, referring to the abaci or the old plaſter pieces cut from the walls, as the tranſlators have rendered them, but to the new plaſter or ſtucco made in the Greek manner, mentioned at the beginning of the paragraph.

work with fly-headed nails[5*]; then plaftering the work again, a fecond coat of reeds is to be fixed perpendicularly, provided the former were placed tranfverfely, and then the arenatum and marmoratum are to be laid as before defcribed; thus by means of the double coat of reeds, fixed againft the walls tranfverfely to each other, neither cracks nor fiffures can happen.

CHAPTER IV.

Of the Plaftering in damp Situations.

I HAVE fpoken of the method of plaftering in dry places; I fhall now explain how it ought to be done in humid fituations, fo that it may remain undamaged.

And firftly, in apartments on the ground ftory, the walls are to be plaftered and made ftraight with brick-duft mortar, to the height of three feet from the pavement, that in that part the ftucco may not be damaged by the humidity; but in walls that are continually damp, another thin wall is to be built withinfide, as far diftant from the other as neceffary, and between the two walls a channel is to be made lower than the pavement of the apartment, having openings to fome uncovered place; alfo, when the wall is erected, vent holes are to be left; for if the humidity have not vent at the top as well as at the bottom, it will penetrate into the new wall: this done, the wall is to be plaftered and made even with brick-duft mortar, and then fmoothed with ftucco. If the place fhould not admit of a wall being built, channels are to be made, with holes from thence to the outfide; then two feet tiles are laid, one fide refting on the margin of the channel, the other on little eight inch brick piers, upon which the angles of two tiles may reft, and not be farther from the wall than one palm; upon thefe upright bent tiles are fixed from the bottom to the top of the wall, their inner fide being well pitched, that the water may be rejected: alfo at the bottom and at the top, above the ceiling, vent holes are to be made; then the tiles are to be whitened with lime diluted with water, that the plaftering may adhere, for on account of the drynefs which they have acquired in the furnace, they cannot receive nor fupport the plaftering unlefs

(5*) *Clavis mufcariis.* Galiani obferves that they now ufe in Italy a fort of nails called *mofcar dini*, from the refemblance of the head to the body of a fly; and conjectures, from the fimilarity of their name and ufe, that they are probably the fame fort that were formerly ufed by the antient Romans.

lime is applied, which adhering to both fubftances, connects them together; with the brick-duft mortar it is then plaftered and made even, and all the reft, as before written, being done, it is laftly finifhed with ftucco.

Concerning the ornaments of the plaftering, they muft be regulated by the rules of decor; fo that being adapted to the places, and not unfuitable to the peculiar circumftances, they may acquire approbation.

In winter tricliniums, neither thefe ornaments nor paintings are proper, nor fhould the cornices of the ceilings be minutely ornamented, becaufe they are fpoiled by the fmoke from the fire, and the foot from number of lights; but in thefe apartments the abaci (or pannels) above the podium are coloured black, and polifhed with yellow or red ornaments intermixed.[1*]

When the ceilings are finifhed and polifhed, then with regard to the pavements it may not be amifs to defcribe the method ufed by the Greeks in their winter apartments, which, though lefs fumptuous, are more convenient. They dig into the floor of the triclinium about the depth of two feet, and the bottom being well rammed, either rudus or teftaceous pavement is laid, having an inclination toward the holes of the drains; then a compofition is made of pounded coals, with fand, lime, and afhes mixed together, and laid even and level half a foot in thicknefs, and the furface being rubbed with ftones, it appears like a kind of black pavement: and at their feafts, the liquid that may fall thereon from the cups or their mouths, is dried up as foon as it falls. And even if the attendants have their feet naked, they receive no cold from thefe kind of pavements.

(1*) *Abaci exatramenta funt fubigendi & poliendi, cuneis filaceis feu miniaceis interpofitis.*

The words filaceis and miniaceis, which come from fil and minium, explained in the following chapter, have been ufually tranflated yellow and red; but *filaceis*, in my opinion, fignifies all ochreous colours, not yellow only; wherefore I have chofen to give the original words.

6

The word cuneis is tranflated by Perrault, triangles, and by Galiani, fquares. I underftand it in this cafe to fignify either ornaments in general, or fome particular fort in ufe at that time.

CHAPTER V.

Of the Manner of Painting in Edifices.

IN other apartments, that is, in thofe for fpring, autumn and fummer, as alfo in the atrium and periftylium, the ancients have eftablifhed certain methods of painting. A picture is the reprefentation of things that are, or may be; as men, buildings, fhips, and other things; of which the copy, by having the exact form and outlines of the real body, affumes the likenefs. The ancients, who originally inftituted this manner of decoration, at firft imitated the varieties and marks of marble incruftation, then cornices, difpofing between them divers filaceous and miniaceous coloured ornaments: they proceeded afterward to reprefent edifices, with columns and pediments projecting; but in fpacious places, fuch as exedræ, on account of the amplitude of the walls, they reprefented the fronts of fcenes in the tragic, comic, or fatyric manner; and ambulatories, being of a great length, they ornamented with landfcapes, expreffing the appearances of particular places, painting harbours, promontories, fea-coafts, rivers, fountains, canals, temples, groves, mountains, cattle and fhepherds; in fome places alfo, large paintings of figures, reprefenting the gods, or fabulous hiftories; the Trojan war, or the wanderings of Ulyffes, and other fubjects of a fimilar kind, which are conformable to the nature of things.

But thefe fubjects, which our forefathers copied from nature, are now, by our depraved manners, difapproved; for monfters, rather than the refemblances of natural objects, are painted on the ftucco; reeds are fubftituted for columns, and for the pediments, fluted harpaginetuli[1*], with curling foliage and volutes; alfo candelabra fupporting the forms of little buildings, their pediments rifing out of roots, with numerous volutes and tender ftalks, having, contrary to reafon, images fitting on them; fo alfo the flowers from ftalks have half figures fpringing therefrom with heads, fome like thofe of men, fome like thofe of beafts, which

(1*) The word harpaginetuli has exercifed the ingenuity of all the commentators hitherto; their conjectures concerning its fignification are very various, and fome far fetched; the moft probable feems to be that it is derived from *harpago, an hook,* and that it means fome kind of ornament or fcroll, in imitation of fuch an inftrument: but it will be beft explained by referring to the Herculanean paintings, where various grotefque ornaments are feen to be fubftituted for the faftigiums or pediments of the feveral buildings there reprefented.

things neither are nor can be, nor ever were: and this new mode ſo prevails that thoſe who are not judges, diſregard the arts; for how is it poſſible for reeds to ſupport a roof; or candelabra, buildings and the ornaments of pediments; or ſtalks, which are ſo ſlender and ſoft, ſitting figures; or the flowers of ſtalks produce half images? Yet men, being accuſtomed to the ſight of theſe abſurdities, do not cenſure, but are pleaſed with them, without conſidering whether they be proper or not; the judgment, depraved by habit, examines not whether they be according to propriety and the rules of decor[2*]; for pictures ſhould not be approved unleſs they be conformable to truth, even although they be well executed; they ought therefore to be immediately condemned, unleſs they can bear the trial of rational examination, without being diſapproved.

Thus at Tralles, when Apaturius of Alabanda had excellently well painted a ſcene in the little theatre, which with them is called the *Eccleſiaſterion*, and inſtead of columns had placed ſtatues and centaurs, ſupporting the epiſtylium, the circular roof of the dome, and projecting corners of the pediments, and ornamented the cornice with lions' heads, all which have reference to the roofing and eaves of edifices; above theſe nevertheleſs in the epiſcene, domes, porticos, ſemi-pediments, and all the various parts of buildings were again painted: wherefore upon the appearance of this ſcene, when by reaſon of its enrichment it was found pleaſing to all, and they were ready to applaud the work, Licinius the mathematician then advanced and ſaid, " the Alabandines are ſufficiently intelligent in all civil affairs, but

(2*) Galiani obſerves that Pliny, 35. 10. ſays this ſtyle of painting was invented in the time of Auguſtus, by Ludius; but adds, it is more probable that Ludius was only the propagator, as Vitruvius *here ſays it was in uſe even before his time.* This ſuppoſition ariſes from Galiani taking it for a fact that Vitruvius wrote in the time of Auguſtus; but as there appears no reaſon to doubt the aſſertion of Pliny in this caſe, the paſſage is rather an evidence that Vitruvius wrote after the time of Auguſtus, ſince he intimates that it had been invented and in uſe before the time he wrote: but the fact is, Galiani has miſtaken the ſtyle of painting Pliny ſpeaks of; it is not the groteſque ſtyle here cenſured by Vitruvius, but the approved ſtyle that he has immediately before mentioned and ſaid was uſed by the ancients: this will be evident by comparing the deſcriptions of the two authors, in which ſeveral of the words made uſe of are the very ſame.—Pliny, b. 35. ch. 10. ſays, " non fraudando & Ludio & divi " Auguſti ætate, qui primus inſtituit amœniſſimam parie- " tum picturam, villas & porticus ac topiaria opera, lucos, " nemora, colles, piſcinas, euripos, amnes, littora, &c.— " not to deprive of due honour, Ludius, who, in the " time of the deified Auguſtus, firſt invented that moſt " pleaſant manner of painting the walls with villas, por- " ticos, landſcapes, woods, groves, hills, fiſh-ponds, " canals, rivers, ſea-coaſts, &c." Theſe are all real objects, ſimilar to thoſe Vitruvius enumerates and approves. This ſtyle, Pliny ſays, was invented in the time of Auguſtus, and this is the ſtyle Vitruvius ſays was invented and uſed by the ancients, but which at his time had given place to the groteſque ſtyle. Theſe circumſtances, therefore, muſt amount almoſt to demonſtration that Vitruvius wrote at a time long after that of Auguſtus: this may therefore be added to the arguments on that conteſted point, in the Obſervations on the Life of Vitruvius.

The groteſque kind of painting was firſt diſcovered by the moderns in the baths of Titus at Rome, and was imitated by Raphael at the Vatican; ſince which it has continued to be in uſe. It is ſaid to have obtained its name from being firſt ſeen in vaulted apartments, which being almoſt buried in the earth and ruins, appeared like caves or *grottos*, from whence came the term *groteſque*.

for a trifling impropriety are deemed injudicious; for the ſtatues in their gymnaſium are all in the attitude of pleading cauſes, while thoſe in the forum are holding the diſcus, or in the attitude of running or playing with balls; ſo that the unſuitableneſs of the attitudes of the figures to the purpoſes of the places, throws a public diſgrace upon the city. Let us then take care that by the ſcene of Apaturius we are not deemed Alabandines, or even Abderites[3*]; for who among you places upon the tiles of the roofs of your houſes columns or pediments? Theſe things are placed upon the floors, not upon the tiles. If then we approve in painting what cannot be in fact, we of this city ſhall be like thoſe who, on account of the ſame error, are deemed illiterate." Apaturius dared not to reply, but took down the ſcene and altered it ſo as to be conſiſtent to truth; after which it was approved. I wiſh the immortal gods would reſtore Licinius to life, that he might correct this folly, and faſhionable disfigurement of our ſtucco work: but why a falſe overcomes a juſt mode, it will not be foreign to the purpoſe to explain.

The ancients, with labour and application, endeavoured to make their works be approved by the excellencies of art; this is now ſupplied by the beauty of colours, and the uſe of thoſe of the moſt coſtly kind; and that value which was formerly given to works by the ſkill of the artiſt, is not deſired, ſince the expence of the proprietor ſupplies its place. Who among the ancients is known to have uſed minium otherwiſe than ſparingly and as a medicine? But now it is every where laid over the whole wall; it is the ſame with cryſocolla, oſtrum and armenium, which when laid, although without any art, appear very brilliant to the ſight; and they are ſo coſtly, that it is uſually ſpecified in the articles of agreement that they ſhall be purchaſed by the proprietor and not by the contractor.

I have explained as well as I am able the means by which defects in the ſtucco work may be avoided: I ſhall now ſpeak of the other requiſite materials as they may occur; and as the lime has been before mentioned, the marble (powder) remains to be treated of.

(3*) The Abderites was a nation proverbially accounted ſtupid.

CHAPTER VI.

Of the Preparation of Marble Powder for the Stucco.

MARBLE of the ſame kind is not produced in all countries ; but in ſome places there grow pieces that have pellucid particles like ſalts, which being pounded and ground, is very proper for the ſtucco work and cornices: but in places where plenty of theſe are not to be had, the marble chips or aſſulæ, as they are called, which come from marble in working it, are to be pounded with iron peſtles, and ſifted in ſieves; then being ſeparated into three ſorts, the larger ſort, mixed with lime, as before deſcribed for the arenatum, is firſt laid, then the ſecond, and laſtly the third, which is the fineſt ſort: theſe being laid, and the ſtucco well levigated and rubbed, the colours are next to be conſidered, that they may appear bright and ſplendid: the differences and preparation of theſe are as follow.

CHAPTER VII.

Of Colours, and firſt of Ochres.

SOME colours are generated in certain places, and are dug from thence; ſome are produced from working, combining, or tempering other things ſo as to anſwer the ſame purpoſe in the work: but we will firſt diſcourſe of thoſe which grow of themſelves, and are dug out of the earth.

That which the Greeks called *ochræ* is found in many places as well as in Italy, but the beſt is that of Attica, which is not now to be had: but at the time the ſilver mines at Athens were wrought, whenever in digging they found a ſtrong vein (of ochre), they followed it as if it

had been ſilver; the ancients therefore had plenty of excellent ſil[1*] for the colouring of their ſtucco work. Rubrica[2*] is alſo found plentifully in many places; but the beſt at few, as at Sinope in Pontus, and in Egypt, in the Spaniſh Balearic iſlands, as well as at Lemnos, the revenue of which iſlands, the ſenate and people of Rome granted to the Athenians.

Paraetonium takes its name from the place where it is dug; ſo alſo does melinum[3*], which mineral is ſo called from Melus, one of the iſlands of the Cyclades. Green earth grows alſo in many places, but the beſt at Smyrna; this the Greeks call *Theodotion*, becauſe Theodotus was the name of him in whoſe land it was firſt diſcovered.

Auripigmentum[4*], which by the Greeks is called *arſenicon*, is dug at Pontus: ſandara[5*] alſo at many places, but the beſt at the mine near the river Hypanis in Pontus; in ſome places, as between the confines of Magneſia and Epheſus, are pits where it is dug ſo well prepared, that it neither requires to be ground nor ſifted, being as fine as thoſe which are bruiſed and kneaded by the hand.

(1*) Whether the ſubſtance called by the Latins *ſil* was the ſame as that the Greeks called *ochre* has been doubted: that it was the ſame ſeems to me moſt probable, as it was found as ochre is, in or near mines of metal, and was, like it, a coloured earth. Pliny, book 33. chap. 12. ſays, *Sil proprie limus eſt,—ſil is a kind of clay.* Galiani endeavours to prove by the word ſil, that the Romans meant no other coloured earth but the yellow, or that now called yellow ochre; and he alleges in favour of his opinion, that Pliny ſays the Attic and Gallic ſil was uſed for the lights of pictures, and muſt therefore be of a light colour. This is true; but Pliny alſo ſays the ſil of Syros and Lydia was uſed for the ſhades, which proves there was dark as well as light coloured ſil.

(2*) Rubrica is a red earth. Pliny, b. 35. ch. 6. ſays it was nearly of the colour of minium, which it was uſed to adulterate.

(3*) Paraetonium and melinum were, according to Pliny, white earths; the former came from a place of the ſame name in Egypt, and was adulterated with boiled fullers earth.

(4*) Auripigmentum, or arſenic, as here called, is ſuppoſed to be that ſubſtance which we call orpiment. Pliny deſcribes it, b. 33. ch. 4. to be of the colour of gold. It is found, he ſuppoſes, in gold, ſilver, and copper mines, and ſometimes in beds of marle. Our orpiment is arſenic with a portion of ſulphur.

(5*) Sandara, Pliny, b. 34. ch. 18. alſo ſays is found in gold and ſilver mines, and is a little paler than arſenicum, which is of the colour of gold: at b. 35. ch. 6. he ſays it grows on the iſland of Topazus in the Red Sea; that it ought to be of a flame colour, and is counterfeited and adulterated with ceruſe or white lead burnt. I muſt notice, for the benefit of his readers, that Galiani has here, and at the 12th chapter, tranſlated *ſandaraca*, minium, or red-lead, urging as a proof, that Vitruvius there ſays ſandaraca was made by burning ceruſe: this is true; but ceruſe, by a certain degree of burning, becomes yellow, growing red when burnt in a greater degree; and the foregoing quotations of Pliny plainly prove that ſandaric was of a yellow or flame colour, paler than auripigmentum, and therefore cannot be the modern minium, which is of a bright red colour.

Pliny more nearly deſcribes minium under the name of uſta. See note 2. ch. 11. following.

There is a gum alſo called ſandaric, which is obtained from the juniper tree.

CHAPTER VIII.

Of Minium.

WE now proceed to the defcription of minium[1*]: this is reported to have been found in the Cilbian fields of Ephefus; the fubftance as well as the procefs relative thereto is fufficiently curious; for when the mafs is dug up, before it is wrought into minium, it is called *anthrax:* it appears like the ore of iron, but is a little redder, having a red powder about it after it is dug; being beaten with iron inftruments, it yields many drops of quickfilver, which the miners immediately gather. When the maffes are collected in the laboratory, being full of moifture, they are thrown into a furnace to be thoroughly dried; and that vapour which is raifed from them by the heat of the fire is, when it fubfides on the floor of the furnace, found to be quickfilver: the maffes are then taken out, and the drops that remain, being too fmall to be collected, are poured into a veffel of water, where they run together and unite. This quickfilver, when it meafures four fextarii, will be found to weigh one hundred pounds; and being put into any veffel, if a ftone weighing a hundred pounds is laid thereon, it will fwim on the furface, nor can it by its weight deprefs, dafh over, or difperfe the liquid; yet upon removing the hundred weight, if a fcruple of gold be laid thereon, it will not fwim, but fink to the bottom by its own weight[2*]. It is therefore not to be denied that the gravity of bodies is not owing to the greatnefs of their weight, but to their peculiar nature.

Quickfilver is found ferviceable for many purpofes; for without it, neither filver nor brafs can be properly gilded; and when garments embroidered with gold are decayed by age,

(1*) The fubftance which we call minium is a preparation of lead, being cerufe or white lead burnt till it becomes red; thence alfo called red lead: but the minium of the antients appears by the defcription to be that fubftance which we know by the name of native cinnabar, or vermilion. Pliny, b. 33. ch. 7. fays it is found in filver mines, was firft difcovered by Callias, an Athenian, in the 349th year of Rome, is in colour like coccum, (which we call kermes), and like the hæmatites or bloodftone burnt. He obferves, fome erroneoufly called it cinnabar, which was the Indian name of dragon's blood; and that on account of the dearnefs of both cinnabar and minium, they ufed rubrica and finopis in their ftead.

He alfo defcribes another fort of minium found in lead and filver mines, and which is not red till it is burnt: this may probably be a part of the metal corroded by fome acid in the mine, and thereby brought to the ftate of cerufe, and which, like it, when burnt, turns red; with this and fyricum, Pliny fays they adulterated the true minium.

(2*) The fpecific gravity of the ftone being lefs than that of quickfilver, and that of the gold being greater.

and can no longer with decency be worn, being burnt in an earthen veſſel over the fire, and the aſhes thrown into water, upon adding quickſilver thereto, it attracts all the particles of gold, and unites them with itſelf; then the water being diſcharged, it is poured into a cloth,[3*] and there preſſed with the hands, by which the quickſilver, on account of its fluidity, is forced through the pores of the cloth, and the pure gold is found compreſſed together within.

CHAPTER IX.

Of the Preparation of Minium.

WE now return to the preparation of minium: when the maſſes are hard, they are pounded with iron tools, and ground, and then by frequent waſhing and boiling they are brought to their colour; when this ſhall be effected, then the minium, by being deprived of the quickſilver, which has in itſelf ſome natural properties, is left, and becomes of a ſoft and weak nature; therefore when laid on the ſtucco, within apartments, it retains its colour without fading: but in uncovered places, as periſtyliums, exedræ, and ſuch like, into which the ſun and moon can ſhine and emit their rays, it is by their contact vitiated, and loſing its brightneſs, becomes of a dull colour: thus among many others, the ſecretary Faberius, intending to have his houſe on the Aventine Mount elegantly decorated, had all the walls of the periſtylium coloured with minium; but after thirty days, it changed of various and diſagreeable colours, wherefore he directly ordered other colours to be laid.

But whoever would be more curious, and would have the minium retain its colour, muſt, when the wall is finiſhed and dried, lay over it, with a hog's hair bruſh, a coat of punic wax, melted and tempered with a little oil; then with burning coals in an iron veſſel, thoroughly heat the wall and the wax till it diſſolves and lies even; afterward with a roll of clean linen rub it as they do naked marble ſtatues: this is called cauſtis by the Greeks; and this coat of punic wax will prevent the rays of the ſun and moon from extracting the colour.

(3*) Pliny ſays a ſkin of leather: in pelles ſubactus effunditur. See l: 33. ch. 6.

Those laboratories that used to be at the mines of Ephesus, are now removed to Rome, because mines of the same kind have been since discovered in Spain, from whence the masses of earth are brought, and worked by a public society at Rome: these laboratories are between the temples of Flora and Quirinus.[1*]

Minium is adulterated with a mixture of lime; whoever therefore would try if it be good, must proceed thus: take a plate of iron, and laying the minium thereon, place it on the fire till the plate be red hot; when its bright colour is changed, and it appears dark, take it from the fire, and if, when it is cold, it becomes of its original colour, it is a proof that it is pure; but if it remains of a dark colour, it is a sign that it is adulterated. I have now mentioned what occurred to me concerning minium. Chrysocolla[2*] is brought from Macedonia, and is dug in those places which are near copper mines; minium and indicum[3*] also by their names indicate in what places they are generated.

(1*) Which stood on the Quirinal Mount.

(2*) *Chrysocolla, glutium auri. Gold solder,* so called, because used for the soldering of gold. Pliny describes it at book 33. ch. 5. He says that it was formed by water flowing through the veins of metal being indurated by the cold of winter; and that it was also made by art: in that manner it was found in mines of different metal; but that of copper mines was most esteemed. It was called luteum from the herb of that name, with which and alum it was brought to its colour before it could be used: this substance we now call borax; it is brought to us from the East Indies, and is white: but it is said to take a different colour according to the mine from whence it comes, being yellow if from a gold mine, white from silver, black from lead, and green from a copper mine, which latter must be that here spoken of by Vitruvius, who says it was found near copper mines: and at the 14th chapter says, wherever it was scarce they used instead of it a mixture of ceruse and the herb luteum, which made a full green. This Pliny also notices, but says it is a bad and fallacious colour.

(3*) Minium, from the river Minius in Spain, which, as Galiani observes, might have taken its name from the colour, at the time it was found there, rather than the colour from it; especially as the colour was first discovered at Ephesus.

Indicum, from Indicus or India, whence it was brought, according to Pliny, b. 35. ch. 6.

CHAPTER X.

Of factitious Colours, and of Black.

I NOW proceed to ſuch as are made from things of another kind, which, by being wrought, are changed, and acquire the properties of colours: and firſt, I ſhall ſpeak concerning black, of great uſe in all works, that the true manner in which it is prepared and tempered may be known.

A place is built like a laconicum,[1*] and lined with marble ſmoothened and poliſhed; before this is built a little furnace, having holes into the laconicum, and the mouth of which is to be very carefully cloſed, that the flames may not paſs outward; then reſin is put into the furnace, the ſmoke from which is, by the fire, forced through the holes into the laconicum, where it adheres to the walls and curve of the dome; whence being collected, part thereof is levigated with gum, to make ink for the uſe of the copyers of books; the reſt is mixed with ſize, and uſed for colouring the ſtucco on walls.

But if theſe materials cannot be procured, that the work may not be delayed, it will be neceſſary to proceed thus: twigs or chips of the pine tree are to be burned, and the coals, when extinguiſhed, are to be pounded in a mortar with glue, which will make a black for the ſtucco work, not diſpleaſing: ſo likewiſe the lees of wine dried and burnt in a furnace, being ground together with glue, and laid on the work, makes an agreeable black; and the better the wine was, from which it was prepared, the black will not only be better, but will even approach the colour of indicum.[2*]

(1*) The laconicum is mentioned in the 10th chapter of the 5th book.

(2*) Pliny, b. 35. chap. 6. mentions this black, made from the lees of wine, in the ſame manner; but ſays the moſt eſteemed black was that made from the teda or pine, which was adulterated with the ſoot from furnaces, or the baths: he ſpeaks alſo of the black made of burnt ivory, called elephantinum, and of ſome earths which are naturally black.

CHAPTER XI.

Of Ceruleum and Uſta.

THE making of ceruleum[1*] was firſt diſcovered at Alexandria, but was afterward made by Veſtorius of Puteoli: the manner in which it is made is curious enough; ſand together with flowers of nitre are pounded till they become like powder, which being mixed with the groſs filings of Cyprian copper, is wetted ſo that it may adhere together; then it is rolled into balls, with the hands, and left to dry; theſe, when dry, are put into an earthen veſſel, and ſet in a furnace, where the copper and ſand heating together, and giving and receiving the vapours of each other, change their properties, and by the force of the fire are brought to the colour of ceruleum.

Uſta[2*], which is very uſeful in ſtucco work, is thus made: the glebe of good ſil is burnt in the fire till it becomes red-hot, and is then quenched in vinegar, which renders it of a purple colour.

(1*) Pliny, b. 33. ch. 13. ſays ceruleum is a ſand, and diſtinguiſhes three kinds of it which were formerly in uſe, viz. the Egyptian, Scythian and Cyprian; to which he adds the Puteolan and Spaniſh, and another ſort latterly introduced, called Veſtorianum, from the inventor: he adds, it is tinged with the juice of an herb in the ſame manner as chryſocolla, and is counterfeited by boiling violets in water, ſtraining the liquor through a cloth, and then mixing it with eretrian earth.

The ceruleum of the antients is thought to be the ſame as, or ſimilar to, that ſubſtance which we call ſmalt, of a blue or azure colour.

(2*) Uſta, which ſignifies burnt, Pliny, b. 35. ch. 6. ſays, was firſt diſcovered by an accidental fire at Pyræus, which by burning ceruſe that was there in earthen veſſels produced that colour; the beſt came from Aſia, and was called purpura: this ſeems to be the ſame as our minium, or red lead. But Pliny adds, uſta was alſo made at Rome, by burning the ſort of ſil called marmoroſum, and quenching it in vinegar (as Vitruvius relates), and that it was uſed for the ſhades of pictures.

CHAPTER XII.

Of Cerufe, Ærugo and Sandarac.

IT is not foreign to the purpofe to mention how cerufe[1*] and ærugo, which we call eruca, are prepared.

The Rhodians place twigs in tubs, wherein they pour vinegar; upon the twigs they lay maffes of lead, and then clofe the tubs with covers, fo that the vapours may not exhale: after a certain time they are opened, and the maffes of lead are found to be changed to cerufe.

In the fame manner laying plates of copper, they become ærugo[2*], which is called eruca.

But cerufe, when burnt in a furnace, changes colour by means of the fire, and becomes like fandarac[3*]; which effect men learnt by an accidental fire[4*]; and this is much better for ufe than even that which grows, and is dug from the mine[5*].

(1*) Cerufe or white lead is well known to be lead, corroded by an acid vapour; vinegar is generally ufed for that purpofe, by which the lead is corroded and changed to a white fubftance. Pliny, b. 34. ch. 17. mentions its being made in the fame manner.

(2*) Ærugo, or copper ruft, is by us called verdigrife; it is of a green or bluifh green colour. Pliny, b. 34. ch. 11. agrees with Vitruvius in the manner of its being made; he adds, it is fometimes adulterated with marble duft, pumice-ftone, or gum, and with atramentum, or copperas; the former of which may be difcovered by grinding it between the teeth, the latter by burning it in an iron pan; for if it be pure it retains its colour, if not it turns red.

(3*) *Efficitur fandaracha* I have tranflated, ***becomes like fandarac***, meaning like it in colour. The words might be underftood to fignify that cerufe is changed into real fandarac, which I believe is not the fact, the real fort being, in my opinion, a compofition of arfenic and fulphur, like auripigmentum, with which it is mentioned at the 7th chapter foregoing.

(4*) Pliny, b. 35. ch. 6. relates, that it was ufta that was difcovered by an accidental fire, as noticed in the foregoing chapter; but it is probable both ufta and fandarac were difcovered by the fame means, both of them being cerufe burnt in different degrees, or being imitable by fuch means.

(5*) I muft here notice what appears to me an error in Galiani's tranflation. Vitruvius having faid that "cerufe burnt becomes fandarac," adds, "and this is better for ufe than that which is natural, or which grows in the mine." Galiani in his notes upon this paffage, fays, "I bianchi minerali che qui non fi fpecificano fono il melino e il paretonio."—"The white minerals not here fpecified are melinum and paretonium."

This feems to me an evident miftake, for Vitruvius in this paffage is not fpeaking of any white fubftances, but of artificial fandarac; and therefore the unfpecified natural fubftance referred to by the words *that which grows naturally*, cannot be any naturally white earths, but the native fandarac which he has defcribed at the 7th chapter preceding.

CHAPTER XIII.

Of Oftrum.

I BEGIN now to fpeak of oftrum,[1*] which is the deareft and moft excellent of all colours, and has a moft pleafing appearance. This is obtained from the fea fhell-fifh, with which the purple dye is made, and which is not lefs worthy of admiration than any other natural curiofity. It is not of the fame colour in all places where it is produced, but is naturally varied by the fituation of the fun. Such as are gathered near Pontus and Gaul, thofe countries being northerly, are blackifh. Between the fouthern and weftern countries they are found livid. Thofe toward the Equinoctial, eaft and weft, have a violet colour. But fuch as are taken from the fouthern regions, are of a ruddy hue. Thofe therefore which are produced near the ifland of Rhodes, and in other fimilar places, which are near the line of the fun, are red. When thefe conchylia are collected, they are broken to pieces with irons, and the purple humour that oozes out like tears, is drained into a mortar, and ground: this is called oftrum, becaufe it is obtained from fhell-fifh; but this, by reafon of its faltnefs, foon becomes dry, unlefs it be mingled with honey.

(1*) This is the celebrated purple of the antients, the preparation of which is now entirely loft, and the fhell-fifh, from which it was obtained, unknown to the moderns. It is called alfo by the names of murex, conchylium, and purpuriffum.

Pliny, b. 9. ch. 36. gives a defcription of the fifh and the manner of preparing the colour: its hue, he fays, is like that of purple rofes; he diftinguifhes the conchylium as yielding a colour more dull and inclining to blue. Vitruvius fays this is the deareft of all colours; and Pliny, at b. 35. ch. 6. mentions purpuriffum alfo, as the deareft of all colours, defcribing it to be a cretaceous earth, faturated with a purple juice; and prefers the Puteolan to the Tyrian, Getulian, or Laconican, becaufe it is firft dyed with hyfginum, and then with the juice of rubia.

But Vitruvius in the following chapter fays that that was the method ufed in making a factitious kind of purple. To reconcile thefe two authors therefore, we muft fuppofe that the juice of the fifh was not ufed alone, but was generally combined with this cretaceous earth, and which might in fome cafes be previoufly dyed with the juice of rubia and hyfginum, to render the colour more rich or vivid.

In Hawkefworth's Account of the Voyage round the World by Captain Cook, mention is made of a kind of fhell-fifh, which they took in latitude 12° 14′ north, and longitude 22° 10′ weft of London, of the fize of a fnail, floating in bubbles of a flimy matter, upon the furface of the fea; and which upon being touched difcharged about a tea-fpoonful of a beautiful purple liquor, that would dye linen cloth. This might anfwer the purpofe of that of the antients, though it does not feem to be the fame fifh, not agreeing with the defcription given by Pliny.

CHAPTER XIV.

Of other factitious Colours,

OTHER purple colours are alfo made by tingeing cretaceous earths with the juice of the roots of rubia[1*] and with hyfginum[2*], as well as other colours, by the means of flowers. Thus the dyers, when they would imitate the Attic fil, put dried violets in a veffel of water, and boil them over the fire; when ready, they pour it in a cloth, and fqueezing this with the hands, receive the violet-coloured water in a mortar, to which adding the Eretrian earth, and grinding it, they produce the colour of the Attic fil.[3*]

In the fame manner, preparing vaccinium[4*] and mixing milk therewith, they make a fine purple. Alfo where chryfocolla cannot be procured on account of its dearnefs, they tinge ceruleum with the herb called luteum[5*], which makes a moft verdant colour. Thefe are called infective colours. Likewife when indicum is wanting; with felinufian or anu-

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(1*) Rubia is that plant we call madder.

(2*) It is not certainly known what is meant by hyfginum; but as Vitruvius fays it was ufed in conjunction with rubia (which gives a red tinge) for making a purple colour, it muft be fuppofed that it yielded a blue colour, and is thought to be the plant we now call woad.

(3*) Pliny, b. 33. ch. 13. fays, they imitated ceruleum in this manner, as noticed at the 11th chap. foregoing. The Attic fil is generally allowed to be of a yellow colour, and to be that which we call yellow ochre; for Pliny obferves that it was ufed for the light parts of pictures, and alfo, that being burnt, it became of the colour of preffum or Syric fil, which he defcribes to be of a ruddy hue, as yellow ochre when burnt becomes.

If then the Attic fil be yellow, and ceruleum blue, how the fame preparation, of the juice of violets and the white Eretrian earth, fhould imitate thofe different coloured fubftances, is difficult to be accounted for, otherwife than by fuppofing that the violets ufed in the two different proceffes were of different forts and hues. This indeed may have been the cafe; for it is thought the antients included by that name feveral forts of flowers, to which the moderns give other names; and Pliny, b. 21. ch. 6. defcribes three forts of violets, the purple, the *yellow*, and the white.

The Eretrian earth, Pliny, b. 35. ch. 16. fays, is of two forts, white and grey, and that it took its name from Eretria, a city of Eubœa; and that a line drawn therewith on copper, appears of a violet colour.

(4*) Vaccinium is alfo unknown; fome have fuppofed it to be the privet, others the blackberry: Perrault thinks it to be the glaftum or woad; and Galiani, the hyacinth: Diofcorides fays it produces a purple flower.

(5*) Luteum, or lutum, is the plant *weld*, which affords a yellow tinge; this being mixed with the blue of ceruleum, makes a green, which is the colour of chryfocolla, as obferved at ch. ix. foregoing.

larian chalk and glaſs, which the Greeks call *yalon*, they make an imitation of the colour indicum.[6*]

In this book I have written what I could recollect concerning the colours for painting, how they ought to be uſed to be durable, and of their reſpective qualities. In ſeven books, therefore, are contained all the rules relative to the perfection and convenience of buildings. In the following I ſhall diſcourſe concerning water, how it may be found, and conducted to the places where it may be wanted, and how to try whether it be good and wholeſome.

(6*) Pliny, b, 35. ch. 6. relates the ſame manner of imitating indicum, which he ſays appears black when pounded, but when diluted, it partakes of the colours of purple and ceruleum : this colour is proved by burning it; for if it be pure, it yields a purple flame, and the ſmoke ſmells like the ſea. Anularia, he ſays, is white, and is made of chalk, mixed with the glaſſy gems from the *rings* of the common people, whence it was called *anularia*.

The ſelinuſian earth, he ſays, b. 35. ch. 16. is of the colour of milk, and eaſily diſſolves in water; mixed with milk, it is uſed to whiten plaſtering.

Vitruvius mentions armenium at the 5th chapter foregoing, but has not deſcribed it. It may not therefore be improper to give Pliny's account of it. At book 35. ch. 6. he ſays, " Armenium is a ſtone which comes from " Armenia, is ſtained in the ſame manner as chryſocolla, " and partakes of the colour of ceruleum, but is a little " lighter."

The Armenian ſtone is now found in Germany, is of a fine blue colour, and differs very little from lapis lazuli, of which the moderns make that excellent blue colour, called ultramarine; except that the former, inſtead of being ſpotted with gold, as the latter is, has ſpecks of a green colour.

END OF THE SEVENTH BOOK.

THE

ARCHITECTURE

OF

M·VITRUVIUS·POLLIO.

BOOK THE EIGHTH.

PROEM.

THALES the Milesian maintained that water was the principle of all things; and Heraclitus, fire; the priests of the Magi, water and fire; Euripides, a disciple of Anaxagoras, whom the Athenians call the scenic philosopher, air and earth, which latter being impregnated by the rain from the heavens, produced men, and all other animals in the world; and as from this they originate, so, when they are dissolved by the course of time, they return thereto again: those also which are produced from air, return to the region of air, nor can they be annihilated; but being only transformed by their dissolution, they revert to the same state in which they before existed.

But Pythagoras, Empedocles, Epicharmus and other naturalists and philosophers, affirm that there are four principles, air, fire, water and earth; and that the union of these, by their natural configuration, produces the qualities of the different kinds of things. We may observe also, that all things are not only produced thereby, but that without their aid, they cannot be nourished, nor grow, nor be preserved: for the body cannot exist without an abundance of air, the influx of which occasions the continual inspiration and expiration; nor without a due proportion of heat in the body, will the mind maintain a due firmness, or the food be properly digested: so also if the members of the body be not nourished by the fruits of the

earth, they become weak, becaufe they are deprived of the mixture of the element of earth; and if animals were without water, they would become languid and withered, from the want of that element.

The divine Mind therefore has not made thofe things which are neceffary to mankind fcarce and difficult to be obtained, as are pearls, gold, filver, &c. which neither the body nor nature require; but thofe without which the lives of mortals could not be preferved are placed ready at hand throughout the whole earth: thus, the body requires good air; the air deftined to that purpofe affords it the heat of the fun and of culinary fire, which give warmth, and render life more comfortable. The produce of the earth affording a fuperabundance of food, fupports and nourifhes the animals continually feeding thereon; and water not only for drink, but for a number of other neceffary purpofes, as agreeable as it is plentiful, fupplies our wants: wherefore the priefts, who perform the rites of the Ægyptians, teach, that all things confift of water; and when they cover the vafe of water, which is conveyed to the temple with great devotion, they proftrate themfelves on the earth, and with hands raifed toward heaven, return thanks to the divine goodnefs for its production.

CHAPTER I.

Of the Manner of finding Water.

AS therefore it is thought by naturalifts, philofophers and priefts, that all things confift of water; and as in the foregoing feven books, the principles of building are explained, I think it proper in this book to write of the means to be ufed in finding water; the qualities it may have from the different natures of places; in what manner it may be conducted, and how it may be tried, it being fo highly neceffary for our exiftence, as well as pleafure and daily ufe.

If there be open running fprings, the work is eafy; but if not, it muft be fought where it is collected under the earth, which may be done thus: before fun-rife, lying proftrate on the place where it is required, and fixing the chin on the earth, look forward, for the chin being

fixed, prevents the ſight from wandering higher than is needful, and confines it to the level of the place; then in thoſe parts where vapours are ſeen gathering and riſing into the air, there dig, for this ſign cannot be in dry places.

In ſeeking for water, the nature of places is to be conſidered; for there are ſome in which it is collected: in clay it is in little quantities, ſhallow, and not of the beſt taſte; in looſe ſand alſo there is but little. If it be found in low places, it will be muddy and ill taſted; but in black earth are found little rills and tricklings, produced by the winter rains, which collect and ſettle in compact and hard ſoils: theſe have the beſt taſte. In gravel there is but a moderate quantity, and the ſprings are not certain, but it alſo is of a good flavour: in the maſculine, common, and carbuncle kinds of ſand, it is certain and conſtant, and is withal of a good taſte: in red ſtone ſoils it is good, and is plenty, if it do not ooze through the pores and waſte: at the bottom of mountains, and among flint-ſtones, it is more copious, and is colder and more wholeſome. The ſalt, groſs, and warm ſprings of the open country, are not good, excepting thoſe from mountains, which, flowing under the earth, break forth again in the plains, and where the ſhelter of trees gives them the agreeableneſs of mountain ſprings. Other ſigns, beſides thoſe above written, of the kinds of earth under which there is water, are theſe: the growing of the ſlender bulruſh, the wild willow, the alder, reeds, ivy, and others of a ſimilar kind, which cannot grow or thrive without humidity; theſe uſually grow near lakes, which being lower than the other parts of the country, receive the rain water and floods of winter, and by their concave form retain the water a long time: but theſe ſigns are not to be truſted to, except in thoſe countries and lands (not in lakes) where they have not been planted, but have naturally grown of themſelves.

In places where there are no ſuch indications, the following experiments are to be made: A hole is dug three feet wide each way, and at leaſt five feet deep, and therein, about the time of ſunſet, is placed a baſon of braſs, or lead, or earth, whichever may be ready: this being anointed with oil on the inſide, is turned upſide downward, and the top of the pit is cloſed with reeds or branches, and then covered with earth; the next day it is opened, and if any drops or moiſture be found in the vaſe, that place has water. Alſo, an earthen veſſel unburnt, being put in this pit, covered in the ſame manner, if the place have water, it will, when uncovered, be found moiſt, and be ſoftened by the humidity. A fleece of wool alſo being laid in the pit, if on the following day water can be preſſed out of it, ſhews that the place has water. So if a lamp, prepared with oil, and lighted, be put in the place, and covered, and the next day be not exhauſted, but ſome of the oil and wick remain, and is wet, it is a ſign the place has water, for heat always draws moiſture to itſelf; and if fire be made in the place, and the heated earth ſends forth cloudy vapours, the place has water.

When theſe experiments have been made, and the above-mentioned ſigns perceived, then a well is to be ſunk on the ſpot; and if a ſpring of water be found, many more may be dug thereabout, and, by means of trenches, the water of all conducted to one place. Theſe ſprings are chiefly to be ſought for on mountains, and on the northern ſides; for in ſuch places they are ſweeter, more wholeſome, and in greater plenty, being averted from the courſe of the ſun; and in thoſe places, the trees and ſhrubs grow in greater abundance; the mountains themſelves, by their ſhadows, preventing the rays of the ſun from ſtriking directly on the earth, and exhaling the moiſture: the valleys alſo among the mountains receive the greater part of the rain, and the herbage is there more abundant: by the ſhades of the trees and the mountains, the ſnow is preſerved a longer time; this melting, drains through the pores of the earth, and runs to the loweſt roots of the mountain, from whence iſſuing, it becomes the ſource of rivers.

On the contrary, in the open country there cannot be much water, or if there ſhould, it cannot be wholeſome; becauſe the heat of the ſun, for want of ſhade, exhales the humidity from the plain fields: and even if water ſhould be apparent, the air attracts and diſſipates in the lighteſt, thinneſt, and moſt ſubtile parts, leaving thoſe which are the heavieſt, hardeſt, and moſt unwholeſome, remaining in the ſpring.

CHAPTER II.

Of Rain Water and its Qualities.

THE water therefore collected from rains is the moſt wholeſome, becauſe it is the lighteſt and moſt ſubtile parts, taken from all receptacles of water; then by the motion of the air it is purified, and being condenſed by the weather, deſcends upon the earth: but it rains not ſo frequently in champaign countries as on mountains, or near mountains; becauſe the vapours that aſcend from the earth in a morning at ſun-riſe, whichever way they incline, thruſt forward the air, impelling the vapours before them, and cauſe the gales and increaſing blaſts of wind.

By the winds, on whatever direction they move, the condenſed vapours riſing from ſprings, rivers, lakes and the ſea, by means of the heat of the ſun are abſorbed, and thus raiſed

aloft in clouds; theſe then floating in the waves of air, when they arrive at mountains, being preſſed by them and the wind, on account of their groſſneſs and denſity, are diſperſed in drops, and ſo deſcend upon the earth.

That vapours, clouds and exhalations, ariſe from the earth, this ſeems to be the reaſon: the earth has within itſelf intenſe heat, much cold air, and great bodies of water; from this, when cooled by the night, vapours iſſue during the darkneſs, and clouds riſe from the damp places; then the riſing ſun ſtriking on the globe of the earth, the air heated thereby raiſes the vapours with the dew: of this the baths afford an example; for ſome of the vaulted ceilings of the Coldaria yield water like ſprings; the air which is there being warmed by the heat of the fire of the furnace, abſorbs the water from the pavement, carries it with itſelf to the ceilings, and there ſuſtains it; for heated air always forces itſelf upward: at firſt it does not deſcend on account of its rarity; but as ſoon as, by the addition of more vapour, it has acquired body, it, on account of its gravity, can no longer be ſupported, but falls in drops on the heads of thoſe who are bathing.

For the ſame reaſons, the air of the atmoſphere, when warmed by the ſun, extracts the moiſture from all places, and gathers it into clouds; for the earth when heated ejects vapours, as the bodies of men when warm emit ſweat. The winds are alſo proofs of theſe things; for thoſe which come from the coldeſt parts, as ſeptentrio and aquilo, blow pure and dry air; but auſter, and others that come from under the courſe of the ſun, are humid, and always bring rain; for being heated by the torrid regions as they come, they imbibe vapours from all the countries in their way, and pour them upon the northern regions.

That this is ſo, is evinced from the ſources of rivers, according as delineated on the map of the earth, and as deſcribed for the moſt part, and generally being found to ariſe in the northern parts: and firſt in India, there are the Ganges and Indus, which ſpring from mount Caucaſus; in Syria, the Tygris and Euphrates [1*]; in Pontus alſo in Aſia, are the Boryſthenes, Hypanis and Tanaïs [2*]; in Colchis, the Phaſis; in Gaul, the Rhone; and in Belgia, the

(1*) Theſe rivers are in that part of Aſia called Aſſyria, which, with Cœloſyria, Leucoſyria and Syria proper, were oftentimes included under the general name of Syria.

(2*) Neither of theſe three rivers are now deemed to be in Pontus, or even in Aſia, according to the modern geography, but in Europe, the Boryſthenes being that now called the Nieper; the Hypanis, the Bog; and the Tanaïs, now the Don, dividing Europe and Aſia. Vitruvius however repeats this in two other places, the firſt at the 7th chapter of the 7th book, and again, further on in this chapter.

Pliny alſo, in his Natural Hiſtory, b. 11. chap. 36.

Rhine; ſouthward of the Alps are the Timavus and the Po; in Italy, the Tiber; in Maurufia, which we call Mauritania, the Dyris, which ſprings from mount Atlas, riſing in the northern parts, and running by the weſt to the lake Eptabolum, where changing its name, it is called the Niger; then from the lake Eptabolum it flows under deſart mountains toward the ſouth, and enters the marſh Coloe, which ſurrounds Meroe in the ſouthern kingdom of Ethiopia; from this marſh, turning by the rivers Aſtaſobam and Aſtaboram, and ſeveral others, it comes through the mountains to the Cataracts, down which precipitating itſelf northernly, it paſſes between Elephantis and Syene, and the Theban fields in Egypt, where it is called the Nile. That the head of the Nile riſes in Mauritania is chiefly known, becauſe on the other ſide of mount Atlas there are alſo ſome heads of rivers which run into the Weſtern Ocean, and in which are bred the ichneumon, the crocodile, and other beaſts and fiſh of a ſimilar kind, as well as the hippopotamos.

As therefore all the great rivers are, according to the map of the earth, found to flow from the north, and the country of Africa, which is in the ſouthern parts, under the courſe of the ſun, has its moiſture concealed within, and has very few ſprings or rivers, it argues that the ſprings which riſe to the north, or north-eaſt, are much the beſt, except they ſhould happen to paſs through ſulphureous, aluminous or bituminous ſoils; for in that caſe they will be changed, and will become warm; or if cold, will have an ill ſmell and taſte; for it is not the natural property of any water to be warm: but when cold water runs through hot ſoils, it effervefces, and, thus heated, iſſues out of the pores of the earth; but it does not long continue warm, but ſoon becomes cold, which were it naturally warm would not happen: the taſte, ſmell and colour, however, are not reſtored, the water on account of the purity of its nature remaining mixed and diſcoloured.

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mentions the river Hypanis being in Pontus: theſe authorities therefore, joined with the conſideration that the antients were well acquainted with that part of the world, favour an opinion that, according to the antient geography, Pontus, and perhaps Aſia, extended ſo far as to include theſe three rivers, differing therein from the modern geography.

CHAPTER III.

Of Spring Water, and its Properties, according to the Minerals it passes; and of the Nature of various Springs, Rivers, and Lakes.

THERE are some hot springs, however, the water of which is of an excellent taste, and are so pleasant in drinking, that the springs of Camoena[1*] or Martia[1*] need not be desired: these are by nature produced in this manner; when, by the means of alum, bitumen, or sulphur, fire is kindled in the earth, and the soil is heated all around, the fervid vapour ascends to the upper parts, where, if there be any springs of pure water, they are heated by the vapour passing through the pores, without having their taste vitiated.

There are also springs of cold water, of a bad smell and taste; these originate in the lower parts, pass through hot places, and then, running a long course under the earth, arrive at the surface cold, but with their smell, taste, and colour, vitiated: such is the river Albula on the Tyburtine way[2*], and the cold spring in the Ardeatine[3*] lands, having the same smell as those waters which are called sulphurati. In other places also there are the same: these, although cold, appear as if they were boiling hot; the reason is, that having fallen from on high into places that were in a state of combustion, the water and fire meeting together with great violence and noise, they have imbibed air, and being thus inflated by the virtue of the compressed air, they issue bubbling from the spring.

Such waters as are not open to the air, but are confined by rocks or other obstacles, are forced by the power of the air, penetrating through the small pores, to the summits of hills; but those who imagine there can be springs so high as the tops of the hills, when they dig a wide well, find themselves mistaken: thus a brass vessel, not quite filled, but being two thirds filled with water, and then covered, when heated by the fire, communicates the heat to the

(1*) The former of these springs was in a wood near Rome, without the gate of St. Sebastian, antiently called Camoena, and afterward Capoena: the latter was one of the aqueducts of Rome, which took its name from the prætor Martius, by whom it was introduced; its source was 36 miles from Rome.

(2*) This river is by the road from Rome to Tivoli, and forms the lake now called Solfatara.

(3*) Near Ardea, in the Campagna di Roma: this water, as well as that of the Albula, was formerly used for bathing.

water; and this, on account of its natural porosity, receiving a strong inflation from the heat, not only fills the vessel, but swelling with the steam, and raising the cover, overflows; yet if, by taking off the cover, the ebullition be exposed to the open air, it subsides again to the same place. In the same manner, when springs are confined by narrow places, the pressure of the air forces the water upward; but as soon as wider apertures are made, having vent by means of the porous quality of the fluid, it sinks, and returns to its proper level.

All hot springs are therefore medicinal; for the water, being boiled with the before-mentioned minerals, acquires qualities useful in some cases; the sulphureous springs relieving the disorders of the nerves, warming and extracting the vitiated humours of the body; the aluminous strengthening the members of the body, when weakened by the palsy or other disorders, and, through the open pores cherishing the frigid parts by the contrary power of heat, relieve, and by repetition restore them to their former healthy state: the bituminous are used in purging potions, to heal the inward disorders of the body. There are also cold springs of a nitrous quality, as those of Pinna, of Vestina, those of Cutilia, and other places; potions of which purge the body, and passing through the intestines, diminish scrophulous tumors. Where gold, silver, iron, copper, lead, and other similar substances, are dug, there are many springs, but they are generally noxious, having qualities contrary to those of the warm springs, which emit sulphur, alum, or bitumen, and, when drank, passing through the veins, affect the muscles and joints, hardening and inflating them; so that the muscles being swollen, contract in their length, and thus afflict men with the cramp, or the gout; for the vessels become saturated with the hardest, grossest, and coldest particles.

There is a sort of water, which, when not cleared enough by the pores, has a scum like a flower floating on its surface, in colour similar to purple glass: this is chiefly observed at Athens, where, from such kind of places and springs, water is conducted to the reservoirs of the city, and of the port of Piræus; but, on account of the quality, it is not drank, the inhabitants using it only for washing and such purposes, and, to avoid any ill effects, drink well-water. At Trœzene the inhabitants cannot avoid this evil; for no other kind of water is to be found, unless they procure that of Cibdelus: in that city, therefore, all, or the greater part of the people are disordered in their feet.

At the city of Tarsus, in Cilicia, is a river called Cydnos, in which those who have the gout, steeping their legs, are relieved of the pain. There are also many other kinds that have peculiar qualities; as the river Himera in Sicily, which, when discharged from the spring, is divided into two streams: that which runs towards Æthna, passing through a soil that contains a sweet juice, is exceedingly sweet; and the other stream, which flows through land from whence they dig salt, has a saline taste.

At Paraetonium alfo, near the road to Hammon,[4*] and from Cafium to Ægypt, there are fenny lakes, which are fo faline, that the falt itfelf congeals on their furfaces; and in feveral other places there are fprings, rivers, and lakes, which, by paffing through falt mines, have neceffarily become falt: fome, flowing through unctuous earth, emerge mingled with oil, as the river called Lipar, near Solæ, a town in Cilicia, in which thofe who fwim or bathe are anointed by the water itfelf. There is a lake likewife in Æthiopia, that anoints the people who fwim in it; and one in India that emits a great quantity of oil in ferene weather. At Carthage there is a fpring, upon which fwims an oil that fmells like filings of citron wood; which oil they ufe to anoint their cattle. In Zacynthos, and about Dirrachium and Apollonia, there are fprings which yield, with the water, a great quantity of pitch.

The vaft lake at Babylon, which is called *Limne Afphaltis*, has a liquid bitumen fwimming upon it; with which bitumen and bricks Semiramis built the walls around Babylon. At Joppa in Syria, and in the Arabia of the Numidians,[5*] there are immenfe lakes that emit large maffes of bitumen, which the inhabitants thereabout collect; nor is this marvellous, for in thofe places there are many quarries of hard bitumen; the waters therefore, rufhing through the bituminous foil, bring it with them, and when they emerge out of the earth, detach it from them, and eject it. In Cappadocia, in the road that is between Mazaca and Tuana, there is a lake, in which if reeds or other things be in part immerfed, and after a day be taken out, that part which was immerfed will be found petrified, while the other part, which was left out of the water, remains in its original ftate. So at Hierapolis, in Phrygia, there is a copious fpring of warm water, which is conducted in trenches around the gardens and vineyards; this in one year forms a cruft of ftone, which they take off yearly from the right and left fides of the trenches, and with it make the partitions of their fields: this happens naturally; for in the country and foil where it is produced, there is a juice of a coagulating nature, which, when mixed with, and difcharged by, the water out of the earth, is, by the heat of the fun and air, fuppofed to be concreted in the manner obferved in falt-pits.

Some fprings, owing to a bitter juice in the earth, are extremely bitter; as the river Hypanis in Pontus, which for about forty miles from the fource is of a fweet tafte; but when it comes to a place that is a hundred and fixty miles from its mouth, it is mixed with

(4*) The temple of Jupiter Ammon in Egypt.
(5*) A part of Arabia formerly poffeffed by the Numidians, an African people inhabiting the fhore of the Mediterranean Sea, near Algiers.

a very ſmall rivulet, which, flowing into it, cauſes ſo large a river to be bitter: for this rivulet paſſing through that kind of earth from whence ſandarac is dug, is thereby rendered bitter. Theſe different taſtes are cauſed by the nature of the ſoil, as is obſerved in fruits; for if the roots of trees, vines, or other plants, produced not the fruits with the juices they receive from the earth, they muſt have the ſame taſte in all places and countries: but it is found otherwiſe; for in the iſle of Leſbos is the wine call *protyrum*; in Mæonia, that called *catacecaumeniten*; in Lydia, the meliton; in Sicily, the mamertinum; in the Campania, the phalernum; in Terracina and Fundi, the cæcubum; and in innumerable other places many kinds of wine of different properties are produced, which could not happen, unleſs the juices of the earth infuſed their peculiar qualities into the roots that nouriſh the ſtem, and thence aſcend to the ſummit, giving the ſeveral kinds of fruits a taſte peculiar to the place: and if the juices of the earth were not different and diſſimilar, then not only in Syria and Arabia would the reeds, bulruſhes, and all the herbs, be odoriferous, and the trees yield frankincenſe, pepper, or myrrh; nor would the ferula laſer[6*] grow only in Cyrene; but in all parts of the earth, and in all places the ſame kinds would be produced.

Theſe varieties, in different countries and places, ariſe from the inclination of the earth's axis, and the influence of the ſun, which affects the juices of the earth, according to their proximity to, or diſtance from, its courſe: and theſe various qualities are obſerved, not only in fruits, but alſo in ſheep and oxen, which could not be ſo differently affected, if the properties of the ſeveral countries of the earth were not influenced by the power of the ſun; for the rivers Cephiſus and Cratis, in Lucania; the Xanthus at Troy; and the ſprings and rivers in the Clazomenean, Erythrean, and Laodicean fields, cauſe the ſheep that, in their breeding time, are daily driven to drink thereof (notwithſtanding they may be white), to produce their young, in ſome places ſpotted, in others of a brown colour, and in others black, the water, when in the body, communicating thereto its own peculiar qualities: becauſe, therefore, the oxen that are bred near a river in the Trojan lands are of a yellowiſh colour, and the ſheep are ſpotted therewith and white, that river is by the Trojans called Xanthus.[7*]

Some kinds of water, by receiving a poiſonous juice from the earth through which they run, are mortal; as the ſpring of Terracina, called Neptunius, of which whoever is ſo imprudent as to drink is deprived of life: for this reaſon, it is ſaid, the antients ſtopped it up. The lake near Cychros, in Thracia, by which not only thoſe who drink, but alſo thoſe who

(6*) Suppoſed to be benzoin, or elſe aſafœtida.

(7*) Which in Greek ſignifies a yellow or orange colour. This river is alſo called the Scamander.

bathe in it, are killed. In Theſſaly is a ſpring that the cattle will never taſte, nor will beaſts of any kind approach: near which ſpring is a tree bearing purple flowers. In Macedonia, likewiſe, at the place where Euripides was buried, two rivulets concur, paſſing on the right and left of the monument: near one, travellers, invited by the goodneſs of the water, are accuſtomed to repoſe themſelves and dine: but the rivulet which is on the other ſide of the monument nobody approaches, becauſe the water is ſaid to be poiſonous.

In Arcadia is a part of the country named *Nonacris*, in the mountains of which are ſtones from whence diſtils an extremely cold water, called *Stygos Hydor* (water of Styx, or ſorrow); which neither ſilver, braſs, or iron veſſels, can contain, for it penetrates through them, and is waſted: nor can any thing contain it but the hoof of a mule. It is related, that Antipater ſent ſome of this water, by his ſon Iollas, to the province where Alexander was, and with it that king was poiſoned. In the kingdom of Cottus in the Alps, is a water, which whoever taſtes immediately dies. In Campus Cornetus, on the Faliſcan land, by the Campanian way, is a grove, where iſſues a ſpring, in which are ſeen the bones of adders, lizards, and others of the ſerpent kind.

Some ſprings are of an acid taſte; as thoſe at Lynceſtes, at Virena[8*] in Italy, at Theano in the Campania, and at many other places; potions of which have the quality of diſſolving the ſtones that form in the bladder of the human body: this may naturally happen; for there is a ſharp and acid juice in the earth, by which the water is rendered acrid; ſo that when in the body, it diſſolves thoſe concretions that ariſe from the ſediments of liquids, and cauſe the pain. That acids will diſſolve theſe things, may be known from this inſtance: an egg being laid in vinegar a long time, its ſhell will be ſoftened, and diſſolved. Lead alſo, which is ſo tough and heavy, being put in a vaſe with vinegar, and cloſe covered, will be diſſolved, and converted to ceruſe. By the ſame means, braſs, which is of a yet harder nature, is corroded and turned to verdigriſe. Pearls, and even flints, which neither iron or fire by itſelf can affect, being, when heated, ſprinkled with vinegar, will break, and be diſſolved. As theſe effects, therefore, happen before our eyes, we may reaſonably judge that acids, on account of their acrimony, may alſo by a ſimilar operation diſſolve the calculous concretions in the body.

Some ſprings there are that ſeem as if they were mixed with wine; as one in Paphlagonia, which, without wine, intoxicates thoſe who drink it. At Equicula in Italy, and among the

(8*) This is generally allowed by the commentators to be an error, and is, from Budeus, corrected to Velino, ſuch a place being known and mentioned by Pliny; whereas Virena in Italy is not known.

nations of the Medulli in the Alps, is a kind of water that cauſes the throats of thoſe who drink it to be ſwollen. In Arcadia is Clitor, a city not unknown, in whoſe territories there is a cavern, from whence iſſues water that makes thoſe who drink of it diſlike wine. At this ſpring a Greek epigram is inſcribed on a ſtone, expreſſing that it is not proper to bathe therein, it being inimical to the vine; for at this ſpring Melampus, by ſacrificial bathings, cured of inſanity the daughters of Prœtus, and reſtored the minds of thoſe virgins to their former ſtate. The epigram is the following:

O! ſhepherd! who com'ſt hither with thy flock
To Clitor's confines, preſt with noontide thirſt,
Drink of this ſpring thou mayſt, and all around
Theſe Naiad nymphs, thy ſhaggy herd may reſt:
But bathe thee not therein, wouldſt thou eſcape
The ills its fumes intoxicating cauſe.
Flee this wine-hating fountain, where Melampus
Bath'd and expurg'd the raving Prœtides
From ev'ry latent taint; when erſt he came
From Argos to theſe wild Arcadian hills.

In the iſland of Chios is a ſpring that makes thoſe who unawares drink of it fooliſh; and here is engraven an epigram, ſignifying that the water is pleaſant to the taſte, but whoever drinks of it will have the ſenſe of a ſtone. The verſes are theſe:

Sweet the cool drops, theſe bubbling waves diſpenſe,
But he who drinks will be a ſtone in ſenſe.

At Suſa in the kingdom of Perſia, is a little ſpring which cauſes thoſe who drink of it to loſe their teeth: here alſo an epigram is written, ſignifying that the water is proper for bathing; but if it be drank, it will extract the teeth from their ſockets. The verſes of the epigram are,

Behold! O paſſenger, this dreadful ſpring!
Thy limbs therein ſecurely mayſt thou bathe;
But if the water thou preſum'ſt to drink,
So ſoon as it ſhall meet the pouting lips,
Straight to the ground the maſticating teeth
Fall, and forſaken leave their vacant ſockets.[9*]

(9*) In De Laet's edition of Vitruvius, it is aſſerted, that theſe epigrams were wanting in all the copies of Vitruvius, till they were reſtored thereto from the writings of Iſigonus; I have however ſeen them in two very antient manuſcripts of Vitruvius, in the Britiſh Muſeum.

Several of the ſprings, here mentioned by Vitruvius, are alſo mentioned by Pliny, l. 31. c. 2. Of that at Clitor, both authors, as well as Ovid and others, ſay, that the drinking of it cauſed a diſguſt to wine; whereas, the Greek epigram itſelf expreſſes that it was bathing in it which produced that effect, and that it might be ſafely drank.

CHAPTER IV.

Of the Properties of ſome other Springs and Countries.

THERE are ſome ſprings which cauſe thoſe who are born near them to have excellent voices for ſinging, as at Tharſus in Magneſia, and at other places. Zama is a city of Africa, which king Juba ſurrounded with a double wall, and there fixed his reſidence. Twenty miles from this, is the town of Iſmuc, whoſe territories have an incredible extent: here, although Africa is the parent and nurſe of wild beaſts and ſerpents, in the lands of this town none breed, and if conveyed there they ſoon die: nor does this happen only on the ſpot; for if the ſoil be carried to any other place, it produces the like effect. The ſame kind of earth is ſaid to be alſo in the Balearic iſlands. That country has likewiſe another wonderful quality, which I thus learnt: C. Julius, the ſon of Maſiniſſa, to whom all the lands of the town belonged, was in the army with Cæſar, the father[1*]: he uſed to be my gueſt; and at our daily meals, we occaſionally diſcourſed on philoſophical ſubjects. Talking one time on the virtues and properties of water, he aſſured me, that in that country there were ſprings of ſuch a kind as cauſed thoſe who were there born, to have excellent voices for ſinging; and therefore they always ſent beyond ſea, to procure handſome ſlaves and maidens of a mature age, and married them together, that thoſe who were born of them, might not only have excellent voices, but alſo be handſome in their perſons.

Thus has Nature eſtabliſhed ſo much variety in different things, that even in the human body only, which conſiſts partly of earth, there are many kinds of humours, as the blood, milk, ſweat, urine, and tears: if, therefore, in ſo ſmall a quantity of matter, fluids of ſuch different properties be found, it is no wonder that in the vaſt maſs of the whole earth, there ſhould be an innumerable variety of juices, through which the ſtreams of water running, arrive tinctured therewith at their ſources, and thus the differences of the climate, and different properties of the earth, produce the peculiar qualities of different ſprings.

(1*) See the Obſervations on the Life of Vitruvius.

Of these things, some I have myself seen, others I have found written in sundry Greek books, the authors of which are Theophrastus, Timœus, Posidonius, Hegesias, Herodotus, Aristides, and Metrodorus; who with great care and study have written of the properties of countries, the virtues of waters, and qualities of different regions, arising from their different climates. From these I have taken, and written, in this book, so much on the varieties of water as I thought sufficient; that men may by these rules readily choose proper water to be conducted for use to the fountains of cities and municipal towns. For of all things, none are so necessary as water; the nature of all animals being such, that if they be deprived of corn, yet by the fruit of trees, or flesh, or fish, or by other foods, they may support life; but without water, neither the bodies of animals, nor any kind of food itself, can grow, be preserved, or prepared: wherefore great care and attention is required that such springs of water be chosen as are salutary to human life.

CHAPTER V.

Of the Means of trying the Goodness of Water.

TRIALS and proofs of water may be thus made: If it be a running stream, and open, before it is begun to be conducted, the people who live adjacent must be observed and examined; and if they have strong bodies, are fresh coloured, have not bad legs, nor sore eyes, it is a proof of the goodness of the water. But if it be a new spring, let it be sprinkled in a Corinthian or other vase, that is of good metal; and if it make no spots, it is good. Also if the water be boiled in a cauldron, and when cold, and poured out, no sand or mud be found at the bottom of the vessel, it is a mark of its goodness. So likewise if pulse, boiled in the water, be quickly cooked, it shews the water to be good and wholesome: and if the water in the spring itself appear limpid, and clear; and where it passes, or runs, neither moss nor rushes grow; nor is the place defiled with any other impurity, but has a clean appearance; these are signs that the water is pure and salubrious.

CHAPTER VI.

Of the Conducting and Levelling of Water; and of the Inftruments for that Purpofe.

I SHALL now explain the manner of conducting water to cities and habitations, in doing which, the firft bufinefs is levelling.

Levelling is performed either by the dioptra, water level, or chorobates; but moft accurately by the chorobates, becaufe the dioptra and water level are liable to error. The chorobates is a ruler (*A*) about twenty feet long: this has ancons (*B*) at the extremities, made perfectly equal, and joined to the ends of the ruler at right angles; and having, between the rulers and ancons, fixed by tenons, tranfverfe pieces (*C*) which have perpendicular lines marked thereon; and perpendicular pendents (*D*) are fufpended from the ruler, one at each end; which, when the ruler is placed, if they equally coincide with the lines defcribed, fhew it to be fituated level: but in cafe the wind fhould difturb the ftrings, fo that they cannot give a true indication, then having a groove (*E*) in the upper part, five feet long, one digit broad, and a digit and a half deep, water is to be poured therein; and when the water equally touches the upper edge of the groove, it fhews it to be level; fo that by the chorobates, when thus levelled, the quantity of the defcent may be known.[1*]

Fig. LXIII.

(1*) The forms of the dioptra and water level of the antients are now unknown; nor is that of the chorobates to be known with certainty from this defcription. The idea of it that occurs to me is different from that of the other tranflators: I do not perceive that the defcription authorifes the making it a kind of cafe, or double frame, of timber work; which muft be very heavy and inconvenient to move. I differ alfo in judging that the ruler, on account of its great length, fhould be fituated edgeways, in order to prevent its bending in the middle; which a ruler of 20 feet, if placed flatways, muft in time do, unlefs made enormoufly thick.

Perrault remarks, that the tranfverfe pieces are faid to be put between the ruler and ancons (*inter regulam & ancones a cardinibus compacta tranfverfaria*); and that, as the ruler and ancons join, there cannot be any thing between them; but the word *inter* is fometimes ufed by Vitruvius to fignify the fpace within, and circumcluded by the parts named; as is obferved at the 21ft chapter of the 10th book: in the prefent cafe, it evidently muft have fuch a meaning; importing that the tranfverfe pieces are fituated fomewhere within the fpace, circumcluded by the ruler and the ancons, or that they in fome way pafs from one to the other. Thefe reafons have led me to imagine that the tranfverfaria may join both thofe members in the manner of braces, CC, Fig. LXIII. fuch braces being highly ufeful, if not neceffary, for holding the ancons in their true rectangular pofition, as well as for ftrengthening the ruler in the middle of its length. In this, however, I pretend not to certainty; it is only an idea, different from the common one, fubmitted to inveftigation.

Perhaps thoſe who have read the books of Archimedes, may ſay, that a true level cannot be obtained by water; becauſe he ſuppoſes water not to be level, but to have a ſpheroidal curve, the center of which is in the ſame place with that of the earth: but whether the water be flat or ſpherical, the extremities of the groove of the ruler muſt equally ſuſtain the water; for if one end declines, the water will not touch the upper edge of the groove of the ruler at the higher end; ſo that notwithſtanding the water may have a ſwelling and curvature in the middle, yet the ends on the right and left muſt, with regard to each other, be on a level. The figure of the chorobates will be deſcribed at the end of the book. If the deſcent is great, the eaſier the water may be conducted; but if the interval ſhould be concavous, recourſe muſt be had to ſubſtruction.

CHAPTER VII.

Of the Manner of conducting Water.

DUCTS of water are made of three kinds; channels of maſonry, leaden pipes, or tubes of fictile ware: of which theſe are the rules.

If channels be uſed, they ſhould be as ſolid as poſſible, and the bed of the ſtream ſhould have a deſcent not leſs than half a foot in a hundred feet. They alſo ſhould be arched over, that the ſun's rays may not touch the water. When it arrives at the city, a caſtellum[1*] is built, and a triple emiſſary to receive the water is adjoined to it. In the caſtellum are three pipes equally diſpoſed within the adjoined receptacles, ſo that when there is too much water, it may, from the ſide ones, be diſcharged into the middle receptacle. Then in the middle one, are fixed the pipes leading to all the ciſterns and fountains; in another, thoſe to the baths, which pay to the people a yearly tribute; and in the third, thoſe to private houſes, if it be not wanted for public uſe: for they could not return it, if they might have peculiar ducts from the ſpring head. The reaſon why this diſpoſition is eſtabliſhed, is, becauſe by

(1*) The receptacle, or reſervoir, was called *caſtellum*, the ruins of ſeveral of which ſtill remain in and near Rome.

the tax on thofe which are carried to private houfes, the public officers keep the aqueducts in repair.

But if there fhould happen to be mountains between the city and the fpring head, the work muft be thus ordered: A fubterraneous paffage is to be dug through the earth, having the defcent before written; then if the foil be either gravel, or ftone, a channel is to be cut therein; but if it fhould be earthy, or fandy, walls, with arches, are to be built in the paffage, and by that means the water conducted. Wells[2*] alfo are to be there made, fo that between every two there may be an actus.[3*]

If the water be conducted by leaden pipes, a caftellum is firft built at the fpring head: then, the lamina of the pipes being fuited to the quantity of water, thefe pipes are laid from this caftellum to that which is in the city. The pipes fhould not be lefs than ten feet in length, each of which, if they be centenariæ, fhould weigh 1200 pounds; if octogenariæ, 960 pounds; if quinquagenariæ, 600 pounds; quadragenariæ, 480 pounds; tricenariæ, 360 pounds; vicenariæ, 240 pounds; quinumdenæ, 180 pounds; denæ, 120 pounds; octonæ, 96 pounds; and quinariæ, 60 pounds. For from the number of digits contained in the breadth of the lamina before it be bent round, the pipes receive their names: thus, when a lamina contains fifty digits, the pipe that is made with it is called quinquagenaria; and fo of the reft.

This manner of conducting water by pipes of lead is thus regulated: If the fpring head have a fufficient current to the city, and there be no higher mountains between, that may be an impediment, the interval is, by walling, raifed to the proper level, as mentioned in the defcription of channels of mafonry; or elfe a circuit round may be taken, if not very long: but if there be frequent valleys, the courfes are to be directed down the declivities, and when ar-

(2*) Putei is the word of the text, here rendered wells; they are fuppofed to be air-holes, cut through from the top of the mountain to the fubterraneous paffage, for the purpofe of giving vent to wind, or vapours which may arife from the water.

(3*) An actus is an hundred and twenty feet. Perrault and Galiani, thinking the diftance of an actus between the wells to be lefs than is neceffary, fuppofe that the number is, by miftake, omitted after the word actus, the rather as the text has *fint actus*, where, if it were fingular, it fhould have been written *fit actus*. Upon examining five manufcripts, I found they all agreed in having *fit actus*, not *fint*, as in the printed editions: and one in the Vatican, here quoted by Galiani, has alfo the fame reading; fo that it feems probable, one actus only is to be underftood; notwithftanding, the wells may be, in this cafe, nearer together than feems to us neceffary.

4

rived at the bottom, a ſubſtructure is to be built, but not high, that the libramentum[4*] may be as long as poſſible. This will be the venter, which the Greeks call *koilian.* When arrived at the oppoſite declivity, as, on account of the length of the venter, it (the water) ſwells gently, it is preſſed upward to the top of the aſcent; whereas, if a venter ſhould not be made in the valley, nor a ſubſtructure built level, but ſhould be bent, the joints of the pipes would be broken and deſtroyed. In the venter, alſo, columnariæ[5*] are to be raiſed, through which the force of the vapours may be diſſipated: thus, thoſe who would conduct water by leaden pipes, may by theſe rules eaſily execute the decurſions, circumductions, venters, and expreſſures[6*].

It will alſo not be unuſeful, when the level from the ſpring head to the city is obtained, to erect a caſtellum at every two hundred actus[7*] diſtance, that if damage ſhould happen at any place, the whole work need not be taken down, and that the defective place may be the eaſier found; but theſe caſtellums ſhould be built, neither in the decurſions, nor in the plane of the venter, nor in the expreſſures, nor in any of the valleys, but always on the even plane.

(4*) The general ſignification of this word is that of level, counterpoiſe, balance, weight, &c. Vitruvius ſometimes uſes it to expreſs that declination from the exact level which is neceſſary to give a proper current to the water. It ſeems here to ſignify all that part of the aqueduct which paſſes down the declivity.

(5*) The columnariæ are probably vent pipes; for Vitruvius ſays they are to give vent to the vapours that may be confined with the water in the pipes; a precaution he has ſeveral times before mentioned. Their names induce a belief that they were perpendicular tubes, like columns, which, being always open at the top, muſt have been ſo high, that their tops might be above the level of the aqueduct; for otherwiſe the water, always preſerving its level, would run out at theſe vents, inſtead of paſſing along the aqueduct.

(6*) By this word, which is written *expreſſus* in the text, is probably to be underſtood that part of the aqueduct where the water riſes, or is raiſed, upward by the weight or preſſure of the deſcending water. For Vitruvius has mentioned no other preſſure or power made uſe of for raiſing the water, nor indeed is any other power neceſſary in theſe caſes, where the water, being incloſed in pipes, will naturally riſe again to the ſame height from which it deſcended.

This chapter may ſerve to remove that erroneous notion which ſome people have conceived, viz. that the antients were ignorant that water confined in tubes will riſe again to the ſame level from which it deſcended, and which they infer from conſidering the great expence, labour, and time, their walled aqueducts muſt have coſt, when the end might have been anſwered ſo much eaſier and cheaper by any kind of pipes. It is here ſufficiently evinced that the antients were well acquainted with this property of water, and that they ſometimes made uſe of it. Pliny, b. 31. ch. 6. alſo expreſsly mentions it.

Health was probably the motive for preferring the walled aqueducts, and for avoiding leaden pipes. Vitruvius mentions hereafter that the water paſſing through ſuch pipes was not deemed wholeſome, on account of its imbibing ſome particles of the lead: and though this objection will not be valid againſt earthen tubes, yet they might not be conſidered as ſufficiently ſubſtantial, and even capacious, to be depended on for ſupplying a great city with the rivers of water daily uſed and waſted; eſpecially in caſes where the water was to be brought from places many miles diſtant.

(7*) If an actus is to be reckoned 120 feet, then 200 actus will equal 24,000 feet. Galiani has written 4000 feet, omitting 20,000, I ſuppoſe by miſtake, and it is not corrected in the errori.

But if it be required to conduct water with lefs expence, it muft be done thus: Tubes of earthen ware are made, having coats not lefs than two inches thick; and thefe tubes are fo made, that one end being tongued, the one may enter the other; then the joints are cemented with quicklime tempered with oil; and in the defcents level with the venter, a ftone of the red kind is placed at the angles, fo perforated, that the laft tube of the decurfus, and firft on the plane of the venter, may be joined to the ftone. So likewife at the oppofite acclivity, the laft in the plane of the venter, and the firft of the expreffure, are to be in the fame manner united to the red ftone.

Thus the tubes on the even plane, as well as thofe in the decurfus and expreffure, will not be ruptured; for fuch violent vapours are apt to arife in conduits of water as would even burft through ftone, unlefs the water was, at firft, gently and fparingly admitted from the fpring, and the bendings fecured with ligatures, or weights of ballaft. In all other refpects they are laid in the fame manner as leaden pipes. When firft the water from the fpring is admitted, afhes are fent before it, that if any of the joints fhould not be fufficiently cemented, they may be ftopped by the afhes.

Aqueducts of tubes have thefe advantages: firft, with regard to the work, if any damage fhould happen, any perfon may rectify it; and then alfo, the water from earthen tubes is more wholefome than that from pipes, as lead is found to be pernicious; for from it is made cerufe, which is faid to be hurtful to the human body; and if that which is made from it is noxious, there is no doubt but that itfelf is alfo unwholefome. This is exemplified by the workers of lead, whofe bodies are of a pallid colour: for when they are melting the lead, the vapour of it fettling on their limbs, and the whole day fcorching them, extracts from the members the juices of the blood. We therefore fhould not conduct water in pipes of lead, if we would have it wholefome; the tafte alfo of that from tubes is better, as is proved at our daily meals; for all perfons, although they have tables furnifhed with vafes of filver, yet ufe fictile ware on account of the purity of the tafte.

But if there be no fpring from whence we may make an aqueduct, it is neceffary to dig wells; and in digging of wells, reafon is not to be difregarded, but the nature of things is with great attention and judgment to be confidered. For the earth generates in itfelf many and various fubftances; it is in fact, like other things, compofed of the four elements; and the firft is itfelf, earth; from moifture it has fprings of water; alfo heat; from whence come fulphur, alum, and bitumen: and air, whence the prodigious vapours, which, when condenfed, pierce through the interftices of the earth to the apertures of wells, and difturb the men who may be there digging, obftructing, by the natural vapour, the breath of their noftrils; fo that whoever does not fpeedily fly, there dies. The means by which this is to

be avoided are these: A lighted lamp is to be let down; and if it remain burning, you may descend without danger; but if it be extinguished by the strength of the vapour, then adjoining the well, on the right and left, æstuaria[8*] are to be dug, that the vapour may be dissipated through the æstuaria, as through nostrils. When this has been done, and the water obtained, then the well may be encompassed with a wall, in such a manner as not to obstruct the spring.

But if the place should be hard, or no spring should be found at the bottom, then by the means of signine work, the water from roofs, or high places, must be preserved. In signine works these rules are to be observed: first, the purest and roughest sand is to be provided; the cementum must be of flint stones broken, so as not to weigh more than a pound; and the lime must be the most ardent. It is so mixed in the pit, that five parts of sand may correspond to two of lime: the cementum is to be added in the pit[9*]: with this the walls of the well, as low as it is sunk, are, by the help of wooden levers armed with iron, to be plastered. The walls being plastered, the earth that may be in the middle is to be taken out quite to the bottom of the walls, and the ground being levelled, the pavement is to be laid with the same mortar, to the thickness intended. If these places be made duple, or triple, so that the water may be filtered in passing through them, it will be rendered more wholesome; for when the mud it may have subsides, the water becomes the clearer, and preserves its taste untainted: if this be not done, it will be necessary to add salt, in order to clarify it.

Of the qualities and varieties of water, with its uses, and the means by which it may be conducted and examined, I have as well as I am able written in this book. The principles of dials and horologia I shall describe in the following.

(8*) If these æstuaria were mere holes, the vapour could as well be discharged through the mouth of the pit as through them; they might indeed hasten the evaporation, but not so much as to be equivalent to the labour and time of digging the holes, or as could be done more speedily by other means at the mouth of the well itself.

(9*) Signinum is noticed at b. 2. ch. 4. where I have observed that I thought Galiani had misapprehended this passage; but I must, in justice to Galiani, acknowledge that I was myself mistaken.

Pliny (35. 12.) speaking of Signinum, says it was composed of lime and the powder of tiles or bricks. At book 7. ch. 4. such a kind of mortar is mentioned by Vitruvius, and directed to be used in damp situations: the words are *arenato testa*, which signifies a composition of lime, sand, and powder of bricks or tiles. And at b. 5. ch. 11. he says, that the seats in the xysti, which were open places, and consequently liable to be damp, were formed of signinum.

The term *signinum* is supposed to be derived from Signia, a town of Italy, where it may have been first used, or invented.

END OF THE EIGHTH BOOK.

5

THE

ARCHITECTURE

OF

M·VITRUVIUS·POLLIO.

BOOK THE NINTH.

PROEM.

THE renowned athletæ who conquered in the Olympian, Pythian, Iſthmian, and Nemean games, were ſo highly honoured by the antient Greeks, that they not only in the aſſembly, adorned with palms and crowns, were applauded; but alſo, when they returned victorious to their own cities, they were carried in triumphant quadrigæ [1*] through the fortifications, and all their life enjoyed an eſtabliſhed proviſion from the public. When I conſider this, I wonder that the ſame, or greater honours are not beſtowed on thoſe authors whoſe works are continually ſerviceable to the whole world; for they are more worthy of ſuch inſtitutions, ſince the athletæ render ſtronger by exerciſe their own bodies only; whereas authors improve not only their own minds, but all others, by preparing books and precepts to enlighten the underſtanding. For what advantage accrued to mankind from Milo the Crotoniat being unconquered, or from others who were victors of that kind, except that among their own citizens they themſelves were ennobled during life? But the precepts of Pytha-

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(1*) Chariots drawn by four horſes a-breaſt, for the entrance of which, on theſe occaſions, it is ſaid the city wall was broken through.

goras, Democritus, Plato, Ariſtoteles, and other ſages, being daily and continually inculcated, not only to their own countrymen, but alſo to all other nations, produce new and conſtant edification; and thoſe who in their youth are fully inſtructed in theſe ſciences, become the wiſeſt of men, and teach the citizens the moral virtues, juſtice, and laws, without which no city can ſubſiſt.

As therefore mankind, both privately and publicly, are ſo benefited by the wiſdom of authors, they ſhould be decreed not only palms and crowns, but alſo triumphs, and adjudged worthy to be placed on the ſeats of the Gods. From many of their diſcoveries which are uſeful in human life, I ſhall ſelect a few as examples, that it may be acknowledged ſuch honours ought to be conferred on them by mankind. And firſt, I ſhall give one of the moſt uſeful, out of many of Plato's inventions, as explained by himſelf.

CHAPTER I.

Of Plato's Method of doubling a Square.

[1*] IF a place or field being ſquare and of equal ſides ſhould be required to be doubled and be ſtill of equal ſides, this, which cannot be done by numbers, may be accurately performed by lines, and it is thus demonſtrated:

The ſquare place being in length and breadth ten feet, contains an area of an hundred feet; if therefore the ſpace be required to be doubled, and to contain two hundred feet, and

(1*) The three firſt chapters of this book are generally allowed to have been intended by Vitruvius as part of the Proem, and erroneouſly divided into the four chapters by the copyiſt. For in this book Vitruvius enters upon the ſecond of the three parts into which he at the beginning divided Architecture, viz. gnomonics, or dialling, to which the ſubject of the ſaid three chapters have no relation; and his addreſs to Cæſar, at the latter part of the third chapter, and manner of concluding it, contributes to confirm this opinion.

I am alſo perſuaded that the firſt chapter of the firſt book was meant by Vitruvius as the proem (that which is called the proem being rather the dedication, or addreſs to the Emperor); for, like the other proems, it conſiſts of hiſtorical narrations and preparatory diſcourſes; and he does not enter regularly upon the ſubject of Architecture, or begin to explain the art, till he comes to that chapter which is uſually numbered the ſecond.

ftill be of equal fides, it is demanded how large each fide of this fquare to contain two hundred feet, anfwering to the double of the given area, muft be made. This cannot be folved by numbers; for if 14 be taken and multiplied into itfelf, it produces 196 feet; if 15, 225 feet: as therefore it cannot be found by numbers, in the fquare (*ABCD*) which is in length and breadth ten feet, the line (*BD*) that extends from angle to angle diagonally, is to be drawn, fo that it may divide the fquare into two triangles (*BAD* and *BCD*) of equal magnitude; the area of each being fifty feet: then with the length of this diagonal line (*BD*) another fquare (*BEFD*) of equal fides is defcribed. Thus as the two triangles formed by the diagonal line in the leffer fquare contain fifty feet each, the fame magnitude, and the fame number of feet, will each of the four triangles (*BAD, BAE, EAF* and *FAD*) in the greater fquare contain. This method of doubling (a fquare) by the means of lines, as here defcribed, was demonftrated by Plato.

Fig. LXIV.

C H A P T E R II.

Of the Method of Pythagoras, for the Formation of a Right-angled Triangle.

PYTHAGORAS fhewed how to form a right angle without the inftruments of artificers; and, although the workmen, with great difficulty, can fcarcely produce a true rectangle, yet by the rules and methods derived from his precepts, it may be done with facility.

Fig. LXV.

For if three rulers be taken, one of which (*AB*) is three feet, the other (*BC*) four feet, and the third (*CA*) five feet, and thefe rulers be fo laid together that their ends may touch one another, they will defcribe the figure of a triangle (*ABC*), and form an exact right angle (at *B*); and if on the length of each of the rulers, a fquare of equal fides be defcribed, the fquare (*ABDE*) which has fides of three feet, will contain an area of nine feet; that (*BCFG*) of four feet, fixteen feet; and that (*CAIH*) of five feet, twenty-five feet; fo that the number of feet in the areas of the two fquares (*AD* and *BF*) whofe fides are three feet, and four feet in length, become equal to the number in that (*AH*) whofe fides are five feet long. When Pythagoras invented this, not doubting but that, in

the difcovery, he had been affifted by the Mufes, to render them the greater thanks, it is faid he offered to them facrifices.[1*]

This principle is ufeful in meafuring, and in many other cafes; it is fo likewife in buildings, for the erection of the ftaircafes, that the afcent of the fteps may have a moderate inclination; for if the height (*AB*) of the ftory be divided into three parts, five of these will be the juft length of the inclined fhafts (*AC*) of the ftairs; for the height of the ftory, whatever it may be, being divided into three parts, four (*BC*) is fet off from the perpendicular (*BA*), and there (at *C*) the interior[2*] footings of the fhafts are fixed; by this means the difpofition of the ftairs, and the afcent of the fteps, will be moderate.[3*]

Fig. LXVI.

(1*) This problem of Pythagoras, as well as that of Plato foregoing, is founded on the 47th propofition of the firft book of Euclid, by which it is demonftrated, that, the fquare of the hypothenufe of any right angled triangle is equal to the fum of the fquares of the two fides. The difcovery of this propofition is generally afcribed to Pythagoras, who, it is faid, ufually facrificed an ox every time he made any difcovery in geometry, but that on this occafion he facrificed an hecatomb.

(2*) Galiani obferves that the word *interiores* fhould be read *inferiores*, or *anteriores*, which appears to me highly probable. I fhould prefer the former, but have not chofen to differ from the text.

The *interior* would probably mean the *under* fide of the fcapi; and in that cafe their upper ends could not abut againft the floor, but would rife wholly above it, or at leaft that part of it from whence the meafures originate.

(3*) By this means the tread of the fteps will be to the rife as 4 to 3, fo that if the tread be a foot broad, the rife will be nine inches, which the moderns in general think too much. We now univerfally fix half a foot, or thereabout, as the ftandard for the rifing of the fteps in convenient ftaircafes; although we often deviate therefrom in particular cafes; and a foot is as generally confidered as the proper breadth of the tread; fo that the breadth or tread of our fteps are to their height or rife, as 2 to 1, and are therefore much lefs fteep than thofe of the antients.

CHAPTER III.

How the Portion of Silver mixed with Gold in any Work may be difcovered and afcertained.

ALTHOUGH the many inventions of Archimedes were wonderful and various, yet this which I fhall relate, feems above all others to indicate his exceeding ingenuity. Hiero being raifed to the regal power in Syracufe, refolved, for the fuccefs of his actions, to dedicate a votive crown of gold, in fome temple of the immortal gods. He determined to have it made of great value, and ordered the quantity of gold to be weighed to the workmen; who at the time appointed prefented the work to the king, curioufly wrought; and the weight of the crown was found to be equal to that of the gold he received. Some time after, however, figns appeared, that part of the gold had been embezzled, and that fo much filver had been mixed with the crown in its ftead. Hiero, offended at this impofition, and not knowing by what means to detect the fraud, defired Archimedes to take the matter into confideration. While he was revolving this in his mind, it happened that he went to the baths, where, when he defcended into the folium,[1*] he obferved, that as much of his body as entered therein, caufed fo much of the water to flow out of the folium. Struck with this method of folving the difficulty, he ftayed no longer, but, tranfported with joy, leaped out of the folium, and running home naked, cryed with a loud voice, he had found what he fought: for as he ran, he frequently exclaimed in Greek, EURECA, EURECA. Upon this principle, it is faid, he made two maffes, each equal to the weight of the crown, one of gold, and the other of filver; this done, he filled a large vafe with water to the brim, in which he put the mafs of filver, whofe bulk, when funk in the vafe, caufed a portion of the water to overflow. Then taking out the mafs, he poured in again the quantity, meafured with a fextarius, that was requifite to fill it to the brim, as before; thus he found what quantity of water correfponded to a certain weight of filver: this being known, he likewife put the mafs of gold into the vafe thus filled, and taking it out, in the fame manner meafured the quantity added, and found that the

(1*) At chapter 10. book 5. Vitruvius calls the bafon that contains the water, *labrum*, where I have obferved, alfo, that it muft be of thofe kinds which are funk below the pavement of the room; but this bafon, that is here called *folium*, is probably of the fmaller kind, that ftood upon the pavement.

quantity of water it had caufed to overflow was not fo great; but was as much lefs as the magnitude of the mafs of gold was lefs than that of the fame weight of filver: laftly, filling again the fame vafe with water, he put therein the crown itfelf, and found that more water was difplaced by the crown, than by the mafs of gold of the fame weight: fo that from the water difplaced by the crown, more than that by the mafs, he difcovered by calculation the quantity of filver mixed with the gold; and thus detected the fraud of the workman.

Let us now transfer our attention to the inventions of Archites the Tarentine, and of Eratofthenes of Cyrene, who have by their mathematical knowledge made many difcoveries ufeful to mankind: and although for other inventions they may be applauded, for the folution of the following problem they are chiefly celebrated. Each undertook to folve, by different methods, the refponfe uttered by Apollo in Delos, to make an altar like his, but containing double the number of cubic feet; and that, thereafter, thofe who might be in that ifland fhould be freed by the religion. This Architas folved by the defcription of the hemicylinder, and Eratofthenes by the mechanifm of the mefolabium.[2*]

(2*) The altar of Apollo at Delos was a cube, and the propofition was to find the meafure of another cube, whofe quantity fhould be exactly double that of the former.

If a cube be formed, whofe fide is double that of the given cube, it will contain eight times the cubical quantity, being the fourth number of a geometrical feries increafing in a duplicate ratio, as 1. 2. 4. 8, and of which the cube required is the fecond number of the feries. It is faid, that Hippocrates, reflecting upon this principle, reduced the propofition to the finding two geometric mean proportionals between two given lines, one equal to the fide of the given cube, and the other, double thereof; the leaft of which mean proportionals will be the meafure of the fide of a cube that fhall be exactly double in quantity to the given cube.

To find thefe two mean proportions, feveral methods were difcovered by the antients. Architas, Eratofthenes, Plato, Nicomedes, Apollonius, and others, have invented different methods; but they are all tentative: thefe may be met with in books of geometry, to which I refer the reader. I fhall, however, here defcribe the principle on which the mechanical contrivance of Eratofthenes was founded.

Fig. LXVIII.

Let *AB* and *CD* be the two given lines, drawn parallel to each other; join *AC* and *BD*, draw the line *AF* to any point *F*, and from the point *F* raife *FE* parallel to *AB*; then from *E* draw the line *EH* parallel to the former line *AF*, and from *H* raife *HG* parallel alfo to *AB*: laftly, from *G* draw *GD* parallel to the former lines *AF* and *EH*, and if the line *GD* interfects the line *CD* in *D*, the operation is right; if not, the direction of the lines *AF*, *EH*, and *GD*, muft be altered till it fo happens; when *EF*, and *GH*, will be the two mean proportionals fought. This method is founded upon the 4th propofition of the 6th book of Euclid, which demonftrates that the correfponding fides of equiangular triangles are proportionals.

By the fame procefs any number of mean proportionals may be found between the two given lines *AB* and *CD*. As every addition to the feveral inventions left us by the antients for finding two mean proportionals, may not be without its ufe, I fhall here annex one that I have difcovered.

BD, *Fig. LXVIII.* is the longeft given line, and *DE* is the fhorteft, perpendicular to the former: continue *BD* toward *C* indefinitely; alfo draw the perpendicular *BA*

As these efforts of the sciences are regarded with so much pleasure, and we are naturally forced to be pleased with such inventions, upon considering their several uses; so on perusing it, I much admire the book of Democritus upon the nature of things, and his commentary which is inscribed *Cheirotoneton*; wherein he used a ring to seal, with red wax, what had been experienced. The studies of such men not only tend to correct the morals of their time, but are also calculated to remain a perpetual benefit to mankind; whereas the feats of the athletæ, in a short time, with their bodies, perish:—so that neither while they are living, nor afterwards, nor by their instructions, can they produce such advantages to human life as are derived from the sentiments of the learned. But although due honours are not afforded to authors, for either their knowledge or instructions, yet by the strength of their own minds, looking above the world, in the memory of succeeding ages they are exalted to the heavens; and they not only render their writings immortal, but also make their very persons known to posterity. Thus, those whose minds are acquainted with the pleasantry of his writings, cannot avoid imagining in themselves the figure of the poet Ennius, in the same manner as those of the gods. And they who are delighted with the study of the poems of Accius, not only feel the energy of his words, but even his resemblance seems to be present with them. Many also, born after our time, will dispute with Lucretius, as if he were before their face, concerning the nature of things; with Cicero on the art of rhetoric; and confer with Varro, upon the Latin tongue. Nor will there be wanting many philosophers, who will seem privately to deliberate and discourse with the sages of Greece. In fine, the sentiments of excellent writers, although their bodies be absent, exist in future ages; and in councils and debates have greater influence than those of the persons who may be present. Supported therefore, O Cæsar, by their authority, and following their opinions and precepts, I have written these books; the first seven, concerning building; the eighth, of water; and

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and the horizontal line EF, indefinitely; then take a rectangle DAC, move the angle A of it up the line AB, moving it from B upwards, and keeping one side AD close to the point D, till the intersections of its two sides AD, AC, with the lines EF and BC, make BC and EF equal; then AB and BC $(=EF)$ will be the two mean proportionals required.

For want of a square, it may be done with a common ruler, or string, though with a little more difficulty, thus: Making the point D the axis, turn the ruler thereon, till the intersections EF and GH be equal, and DH equals AB. To help this latter operation, it will be useful to have a few perpendiculars drawn near about the place where GH, it is guessed, will happen. A demonstration is scarcely necessary, as it will be evident on inspection, that $DE : EF :: EF = CB : BA$, and $:: BA : BD$, they being all similar sides of similar triangles, each having one side common.

The following method of finding two geometric mean proportionals ARITHMETICALLY, has also occurred to me. Multiply the square of one of the given numbers by the other given number, and the cube root of that product will be one of the mean proportionals sought. If the greater of the given numbers be that which is squared, the greater mean proportional will be the result; and the contrary if the lesser given number be squared.

in this I ſhall explain the principles of dials; how they are to be contrived by means of the ſhadows of gnomons cauſed by the rays of the ſun, and on what principles they are enlarged or contracted.

CHAPTER IV.

Of the Conſtellations and Planets, relative to the Principles of Dialling.

THESE things are eſtabliſhed by the divine Mind, and excite great admiration when contemplated. The equinoctial ſhadow of gnomons is of a different magnitude at Athens, at Alexandria, at Rome, at Placentia, and at other parts of the earth, and therefore the forms of dials vary greatly in different places; for by the length of the equinoctial ſhadow are determined the forms of the analemmas,[1*] by which, according to the difference of places, and ſhadows of the gnomons, the hour lines are deſcribed. The analemma is a figure contrived from the obſervation of the courſe of the ſun, and the increaſe of the ſhadow at the winter ſolſtice; and by means of which, with architectonic rules, and the uſe of inſtruments, the appearances in the ſyſtem are deſcribed. The world is the whole aſſemblage of all things in nature, and the heavens figured with the ſtars. Theſe revolve continually around the earth and ſea, upon the extremities of the cardinal (polar) axes; for in thoſe places the cardinal points are by the power of nature formed and ſituated as centers; one, from the earth and ſea, to the world's ſummit, beyond the northern ſtars themſelves; the other, on the contrary, under the earth, to the ſouthern regions; and there, around the cardinal orbicules, as around the centers in wheels, which the Greeks call *Poloi*, the heavens perpetually revolve. Thus the earth, with the ſea, is naturally placed in the middle; theſe are by nature ſo diſpoſed, that in the northern part, the center (the *pole*) is raiſed above the earth; while in the ſouthern part, being confined to the inferior regions, it is concealed by the earth.[2*]

(1*) The analemma is deſcribed at the 8th chapter of this book.

(2*) Vitruvius here ſpeaks according to the Ptolemaic ſyſtem of the world, which was univerſally believed in his time; and according to the local ſituation of Italy, and the other parts of the earth then moſt known, which were wholly, or chiefly, in northern latitudes.

Through the middle, tranfverfely, and inclined to the fouth, is formed the circular broad zone of the twelve figns,[3*] whofe reprefentations are delineated by nature in the difpofitions of their ftars into twelve equal parts, which thus fhining like the reft of the ftars, and revolving round the earth and fea, defcribe their courfe in the fphere of the heavens: but all are vifible and invifible at ftated times; for when fix figns are revolving in heaven above the earth, the others, paffing under the earth, are obfcured by its fhadow. Six of thefe, therefore, are always fhining upon the earth; for as much of the ultimate fign as by the force of the rotation defcends and is hidden under the earth, fo much of the oppofite one is, by the revolving power, raifed to view from the concealed and obfcured parts, as the fame power actuates at once both the eaftern and weftern motions. Thefe figns are in number twelve, and each poffeffes a twelfth part of the heavens, turning continually from eaft to weft: and through thefe figns, but the contrary way, the Moon, Mercury, Venus, the Sun itfelf, as alfo Mars, Jupiter, and Saturn, as if afcending on fteps, run their courfe; traverfing the heavens, in orbits of different magnitudes, from the weft to the eaft. The Moon is twenty-eight days and about an hour more[4*] in paffing the circuit of the heavens, from the fign where it began its motion, to the fame fign returning; thus making a lunar month.

The fun paffes the fpace of a fign, which is the twelfth part of the heavens, in a month; thus pervading the twelve figns in twelve months; when, by returning to the fame fign from which it began its courfe, it meafures the interval of a year. This circuit the Moon paffes thirteen times in twelve months, while the Sun moves round it but once in the fame time.

The planets Mercury and Venus, moving round the Sun itfelf as a center, feem fometimes to be retrograde and to be retarded, as alfo, by the nature of their circuit, to be ftationary and fixed in the place of the figns. This is chiefly obferved in the planet Venus, which, when it follows the Sun, appears in the heavens after funfet, fhining with great luftre, and is called *Vefperugo*; at other times, preceding and rifing before the Sun, it is called *Lucifer*. Thefe are fometimes delayed many days in one fign: at other times they proceed fwiftly in another fign; but although they are not an equal number of days in each fign, as much as they are delayed in a former, with fo much the more celerity paffing the following, they perform their courfe

(3*) Called the zodiac.

(4*) This is not the time of its revolution according to the modern calculation; a periodical revolution of the Moon, which is the time of its paffing from any one fign till it returns to the fame fign again, being now found to be 27 days, 7 hours and 43 minutes; and a fynodical revolution, which is the time between its conjunctions with the Sun, 29 days, 12 hours and 44 minutes. Pliny, l. 2. c. 9. fays the time of the Moon's revolution is 27 days and about the third of a day, nearly agreeing with the modern computation.

exactly; for it so happens, that although they are retarded in some of the signs, yet when they free themselves from the necessary delay, they pass more quickly through the ensuing part of their orbits.

The planet Mercury so revolves in the heavens, that in 360 days, passing the circuit of the signs, it arrives at that sign from whence it began its course; and its path is so equally divided, that it remains about 30 days in each sign.

Venus, when it is freed from the obstructions of the Sun's rays, moves the space of a sign in 40[5*] days; and although it remains less than 40 days in several signs, yet when it is stationary, by being detained in one sign, it regains the whole of its number. Therefore passing round the whole circuit of the heavens in 485 days, it returns again to that sign from which it first began to move.

Mars, in about 683 days traversing the space of the stars, arrives again at the beginning of its course; and though it moves too quick in some signs, yet by being stationary in others, it revolves the just number of days.

Jupiter, with gentler motion ascending the degrees, contrary to the rotation of the heavens, passes through each sign in about 360[6*] days, and is 11 years and 323 days in returning to the sign, in which it was twelve years before.

(5*) This number is written 30 in all the editions; yet the tenor of the whole passage proves it is a mistake, and that it should be 40; for the very next sentence, "Although the planet stays less than 40 days in several "signs, yet that deficiency is supplied by its staying longer "in another sign," clearly implies that Vitruvius meant it to be 40 days, which was about the number he supposed the planet stayed in each of the twelve signs: and also, that number multiplied by 12, equals the number of days he allows to the whole revolution, wanting 5, which may be supposed to be gained by its longer stay or retrogradation in some sign.

(6*) This number 360, and the number 323 following, are in all the printed editions, except Galiani's, written 365, and 363; although, in all the manuscripts I have examined, and in one at the Vatican library, they are as here written in the text. I have therefore, with Galiani, chosen those numbers, as they agree more nearly with Ptolemy's calculation, as well as with the whole period of Jupiter's revolution, mentioned by Vitruvius.

But the times of the revolutions of the several planets, as here determined, by no means agree with the modern calculations, nor indeed with those of other antient writers, particularly in the planets Mercury and Venus, which are different determined both by Ptolemy and Pliny. Ptolemy assigns 124 days to the revolution of the former, and 575 to the latter; and Pliny allows 339 to the former, and 575 to the latter: but these differences are doubtless owing to the false notion the antients had of the mundane system.

The times of the periodical revolutions of the planets

Saturn is 31 months[7*] and a few days more in paſſing the ſpace of a ſign; and in 29 years and about 160 days, it returns to that in which it was thirty years before. This, as it is leſs diſtant from the extremity of heaven, is found to have a larger orbit, and to move ſlower.

Thoſe which make their circuit beyond the path of the Sun, when they are in trine[8*] chiefly, do not proceed, but being retrograde, are delayed till the Sun paſſes from the trinal ſign to another. Some aſſert this to be owing to their being then far diſtant from the Sun, where their paths not being enough enlightened, they are impeded by the obſ rity: but it ſeems not ſo to us, for the brightneſs of the Sun is, without any obſcurity, perceptible and evident throughout the whole world, as appears to us even at the time theſe planets are retrograde and ſtationary. If then it is obſervable at ſuch a diſtance to our view, how can we ſuppoſe that it is obſcure to the divinity and ſplendour of the planets? We therefore rather maintain this principle, that as heat attracts and draws all things to itſelf; for we ſee fruits riſe out of the earth by the means of heat; as alſo by the rainbows, vapours from the ſprings of water riſing to the clouds: ſo for the ſame reaſon, the violent heat of the Sun's rays, extended in a triangular form, attracts the ſucceeding planets, and in the ſame manner ſtopping and retaining thoſe preceding, ſuffers them not to advance, but forces them to return, and remain in the other trinal ſign. It may perhaps be demanded, why the Sun, by its heat, cauſes this detention in the fifth[9*] ſign from itſelf, rather than in the ſecond or third, which are nearer. I ſhall explain this, as it appears to me. Its rays being extended in the heavens ſo as to form

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round the ſun, according to modern calculations, are as follow:

	Days.	Hours.	Min.
Mercury - - -	87	23	
Venus - - - -	224	17	
The Earth - - -	365	5	49
Mars - - - -	686	23	
Jupiter - - - -	4232	12	
Saturn - - - -	10759	8	

(7*) Perrault has obſerved, that if Saturn be 29 years and 160 days in paſſing its revolution, then it can be but 29 months and ſome days in each ſign, allowing 30 days to a month. But to this it may be anſwered, that Vitruvius may poſſibly mean lunar months, at the length he has juſt mentioned, viz. 28 days and about an hour; and in that caſe the words of the text will agree with the truth: for the planet will be 31 of thoſe months, 26 days and an half in each ſign, reckoning the year at 365 days, 5 hours, 49 minutes.

(8*) One of the aſpects of the planets. For the ſake of the following note it may be uſeful to recollect the ſeveral aſpects, conjunction, ſextile, quadrate, trine, and oppoſition: the firſt is when two planets are in the ſame ſign, or place, of the circle of the heavens; the ſecond, when they are 60 degrees, or a ſixth part of the circle diſtant; the third, when they are 90 degrees, or a fourth part of the circle diſtant; the fourth, when they are 120 degrees, or a third part of the circle diſtant; and the fifth, when they are 180 degrees, or half the circle diſtant.

(9*) Perrault has here differed from the text, and written the *fourth* inſtead of the *fifth*, as believing it to be a miſtake, cauſed by the copyiſts omitting the figure I before the figure V, and thus writing V inſtead of IV. Vitruvius undoubtedly means that ſign which is 120 degrees diſtant from the Sun: now as a planet, when it is 120 degrees diſtant from another, or in a trine aſpect, is then in the fifth ſign from it, if the two extreme ſigns be included, it may well be ſuppoſed that Vitruvius meant

a triangle of equal ſides, this will interſect neither further nor nearer than the fifth ſign; for if the rays were diſperſed through the whole world circularly, and not extended in the form of a triangle, the nearer bodies would then be more heated. This Euripides the Greek poet has alſo obſerved; for he ſays that which is further from the Sun has a more intenſe, and that which is nearer, a more moderate, heat: for in the dramatic fable of Phaeton, he writes thus: Καίει τὰ πόῤῥω, τὰ δ' ἐγγὺς εὔκρατ' ἔχει. *The diſtant burns, but gently warms the near.* If then the fact, reaſon, and the teſtimony of an ancient poet ſhew it to be thus, I think it ought not to be ſuppoſed otherwiſe, than as we have before written.

Jupiter performing his circuit between Mars and Saturn, revolves in an orbit greater than that of Mars, and leſs than that of Saturn: and the reſt of the planets, in proportion as they are further from the extremity of heaven, and have their orbits nearer to the earth, are found to move ſwifter: for thoſe which make a leſſer circuit will often paſs thoſe that are above them.

Thus if on a wheel, ſuch as the potters uſe, ſeven ants were put in as many grooves made in the wheel around the center, increaſing from thence to the extremity in which they were obliged to walk round, and the wheel was turned the other way, they would nevertheleſs make their circuit contrary to the rotation of the wheel; and thoſe which were nearer to the center would paſs round ſooner than thoſe at the extremity of the wheel, ſuppoſing they walked with equal celerity; for, on account of the magnitude of the circuit, they muſt be longer in paſſing their courſe. In the ſame manner the planets revolve in their orbits contrary to the courſe of the heavens, although they are carried backward by the prevailing rotation of the heavens in their diurnal motion.

But the reaſon that ſome of the planets are temperate, ſome hot, and ſome cold, is found to be this: that as all fire has a flame aſcending upward, ſo the Sun, by its rays, heating the

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that manner of reckoning, and therefore Perrault ſhould not have ſo haſtily altered the text. But Perrault urges, "that as the text oppoſes the fifth ſign to the ſecond, or "third, by which are meant the two aſpects, ſextile and "quadrate, they would, if that way of reckoning had "been uſed, have been called the third and fourth ſigns."

But this is taking it for certain that Vitruvius meant thoſe two aſpects by thoſe words; whereas it may as well be ſuppoſed that he meant, by the words ſecond and third, the ſigns that were next and next but one to the Sun; and this ſuppoſition will agree more nearly with the chief end and intention of his argument; which is to ſhew why the Sun affects thoſe planets which are farther from it, more than thoſe which are nearer. So in the ſcale of muſic, the note which is the fourth from the fundamental note, is called the fifth, becauſe the two extremes are comprehended, the fundamental note being reckoned the firſt; in the ſame manner Vitruvius may have here reckoned the ſigns.

æther above it, in the place where Mars has its courſe, that planet is rendered fervent by the heat of the Sun. Saturn, which is near the extremities of the world, and in contact with the frozen regions of heaven, is intenſely cold. But Jupiter, whoſe path is between the orbits of both, being qualified by their cold and heat, is found to have a moderate and temperate effect. Thus of the zone of the twelve ſigns, and of the ſeven planets, with their contrary action and courſe, by what laws, and at what times they paſs from ſign to ſign, and perform their circuit, I have diſcourſed according as I have learned from authors. I ſhall now ſpeak of the increaſe and diminution of the light of the Moon, as delivered to us by the antients.

Beroſus, who, from the city or nation of the Chaldeans, travelled in Aſia, and taught the ſciences, maintained the Moon to be a ball, half of which was luminous, and the other part of a blue colour: and that when, in the courſe of its circuit, it paſſes under the orb of the Sun, the rays and violent heat thereof attract and turn the bright ſide by the ſympathy of light to light: ſo that when the globe of the Sun is above it, then the lower part, which is not luminous, is, on account of its ſimilitude (in colour) to the air, inviſible. When it is thus perpendicular to the Sun's rays, the whole light is confined to the upper face, and it is then called the firſt day. When it paſſes the eaſtern part of the heavens, the attraction of the Sun being abated, the extremity of the bright ſide, in a thin line, emits its luſtre to the earth, and it is then called the ſecond day. Thus, by the daily remiſſion of the reverſement, the third and fourth days are numbered. On the ſeventh day, the Sun being in the weſt, the Moon will be between the eaſt and the weſt, in the middle part of the heavens; being then the half of the heavens diſtant from the Sun, the half of the luminous ſide will be turned to the Earth: but when the whole ſpace of heaven is between the Sun and Moon, and the Sun, paſſing the weſt, views the orb of the Moon behind it in the eaſt, being then at the greateſt diſtance from its rays, it is the fourteenth day, and the full circle of the whole diſc emits its light. The remaining days it decreaſes daily, till the completion of the lunar month, and its return to paſs again under the Sun, determining by its monthly rays the number of days. But as Ariſtarchus, the Samian mathematician, has with great judgment taught a different doctrine of the ſame, I ſhall here explain it.

He maintains that the Moon has no light of its own, but is as a ſpeculum (reflector), and receives its light from the Sun: of all the ſeven planets, the Moon revolves in the ſmalleſt orbit, and neareſt to the Earth; therefore the firſt day of every month paſſing under the Sun, it is inviſible; and, becauſe it is with the Sun, it is ſaid to be new. The next day, which is called the ſecond, having paſſed by the Sun, it has a thin illumination on the edge of the circle: the third day of its departure from the Sun, it becomes more illuminated: retiring every day more, at the ſeventh day, being about half the extent of the heavens diſtant from

the weſtern Sun, half of it ſhines; the part that is toward the Sun being illuminated.[10*] On the fourteenth day, when it is the ſpace of the whole heavens diſtant from the Sun, it appears full, and riſes when the Sun ſets: for, being the whole ſpace of the heavens diſtant, it ſtands diametrically oppoſite, and the whole orb receives the light of the Sun. On the ſeventeenth day, when the Sun riſes, it tends toward the weſt: the twenty-firſt day, when the Sun riſes, the Moon is about the middle of the heavens, and that ſide which is next to the Sun is enlightened; the other ſide being in ſhadow. So daily performing its courſe, about the twenty-eighth day,[11*] it again paſſes under the rays of the Sun, and thus completes its monthly rotation. I ſhall now deſcribe how the Sun, paſſing through a ſign every month, lengthens and ſhortens the days and hours.

(10*) "Et ejus quæ ad Solem pars ſpectat ea eſt illuminata"—"The part that is toward the Sun being illuminated." Perrault finds no ſenſe in this paſſage, as here ſituated; he has therefore judged it ſhould be placed a few lines before; i. e. ſo as to follow the word *obſcuratur*, and has rendered his tranſlation accordingly: but theſe words are as applicable, and may be as juſtly ſaid, when the Moon is a quarter of its revolution diſtant from the Sun, as when it is in conjunction; and it is extraordinary that Perrault ſhould think otherwiſe. If the words be equally juſt in both caſes, it is no fault in Vitruvius that they are not placed where Perrault would have them: indeed Perrault ſeems to have haſtily written his ideas, without conſideration, or the uſe of his judgment, in this, as well as in many other alterations that he has made.

(11*) Vitruvius has before in this chapter mentioned 28 days as the time of the *periodical* revolution of the Moon, and here it is applied to its *ſynodical* revolution; with neither of which it exactly agrees. See note 4 foregoing.

CHAPTER V.

Of the Courfe of the Sun through the Twelve Signs of the Zodiac.

WHEN the Sun enters the fign of Aries, and has proceeded an eighth part therein, it caufes the vernal equinox[1*]; when it has advanced to the tail[2*] of Taurus, and to the ftars of Vergiliæ, which are confpicuous in the prior half of Taurus, it has paffed in the heavens more than half *of its courfe to the north*. From Taurus, entering Gemini *at the rifing of the* Vergiliæ, it advances more upon the earth, and increafes the length of the days; then from Gemini entering Cancer, which occupies the leaft part of the heavens, when it arrives at the eighth part thereof, it determines the fummer folftice, and moves on to the head and breaft of Leo; for thofe parts are affigned to Cancer. From the breaft of Leo, and end of Cancer, the Sun, paffing through the remaining part of Leo, diminifhes the length of the days, and its circuit; making the fame courfe as when in Gemini. Paffing from Leo to Virgo, and proceeding to the finus of her veft, it leffens its circuit, and makes a courfe equal to that which it made when in Taurus. Proceeding from the finus of Virgo, which finus includes the firft part of Libra, it produces the autumnal equinox; the circuit being then equal to that it made when in the fign Aries. When the Sun enters Scorpio, at the fetting of the Vergiliæ, it diminifhes the length of the days, proceeding to the fouthern parts. From Scorpio, paffing to the thigh of Sagittarius, it caufes the days to be yet fhorter. From the thighs of Sagittarius, part of which is attributed to Capricornus, entering on eight parts of the latter, it then makes the fhorteft tract in the heavens; which time is, from the fhortnefs of the days, called *Bruma*, and the days *Brumales*. From Capricornus, paffing to Aquarius, it increafes and makes the days equal in length to thofe of Sagittarius: from Aquarius, entering Pifces, at which time the wind Favonius

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(1*) This is not the cafe at prefent; for by a motion that alters the place of the equinoxes about 50 feconds of a degree every year, called the preceffion of the equinoxes, the vernal equinox is moved almoft 30 degrees from the place affigned by the antient aftronomers.

(2*) The conftellation Taurus is reprefented without a tail and hinder parts, on the modern fpheres; whether therefore it was by the antients differently reprefented, or that we are to underftand by this expreffion the extremity of the fign, is uncertain. Pliny, b. 2. ch. 41. mentions the feven ftars called Vergiliæ being in the tail of Taurus.

blows, its courſe is equal to that when in Scorpio: thus the Sun pervading the ſigns at ſtated times, increaſes and diminiſhes the length of the days and hours.[3*]

I ſhall now ſpeak of the other conſtellations that are on the right and left of the Zodiac; and of the ſtars diſpoſed on the northern and ſouthern part of the heavens.

CHAPTER VI.

Of the Conſtellations that are on the North of the Zodiac.

SEPTENTRIO,[1*] which the Greeks name *Arcton*, or *Helicen*, has behind him his Keeper,[2*] who is not far from Virgo; over whoſe right ſhoulder is a moſt brilliant ſtar, called by us *Provindemia Major*, and by the Greeks *Protrygeton*, which ſhines with an extraordinary luſtrous colour; oppoſite to it is another ſtar, between the knees of the Keeper of Arctus, who is called Arcturus. From the head of Septentrio, toward the feet of Gemini, is the part aſſigned to Auriga, who ſtands at the point of the horn of Taurus; alſo at the point of the left horn, by the feet of Auriga, is a ſtar called the Hand of Auriga, by whoſe left ſhoulder are the Goats' Kids. Above Taurus and Aries, is Perſeus, paſſing under, on the right, the baſe of the Vergiliæ, and on the left, the head of Aries; with the right hand reſting upon the figure of Caſſiopeia, the left holding over Auriga[3*] the Gorgon's head, by the top, and laying it under the feet of Andromeda. The Fiſhes alſo, above Andromeda, and by the belly of

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(3*) The Romans divided the day, whether long or ſhort, into twelve hours, as Vitruvius obſerves at the 8th chapter following; beginning at ſun riſe, and ending at ſun-ſet: therefore, in all their dials and contrivances to meaſure time, the hours were lengthened and ſhortened with their days.

(1*) Called alſo *Urſa Major*, the Great Bear.

(2*) Boötes, or Arcturus, according to Vitruvius.

(3*) Galiani has changed *Aurigam*, in the text, to Taurum, becauſe he ſays "Perſeus holds the Gorgon's "head over Taurus, not over Auriga." This is true, if we conſider the north pole as the upper part, as Galiani ſeems to have done; but as Perſeus is diſpoſed with his feet upon Auriga, and his head weſtward, the weſt, with reſpect to him, may be conſidered as the upper part, and Auriga may be ſaid to be below him; conſequently Perſeus, in that view, holds the Gorgon's head over Auriga. This may be the view in which Vitruvius has conceived it, and in this view the text is juſt, and the alteration of Galiani erroneous.

her and of the Horſe, are over the back of the Horſe; and a glittering ſtar limits the belly of the Horſe and the head of Andromeda.

The right hand of Andromeda is placed upon the image of Caſſiopeia, the left over the north-eaſtern Fiſh. Aquarius is over the head of the Horſe, the hoofs [4*] of the Horſe touching the knees of Aquarius: the middle of Caſſiopeia is dedicated to Capricornus. [5*] High above are Aquila and Delphinus; near them is Sagitta; and by him the Swan, of which the right wing touches the hand of Cepheus, whoſe ſceptre, in his left hand, reſts upon Caſſiopeia. The feet of the Horſe are concealed under the tail of the Bird. [6*]

Over Sagittarius, Scorpio and Libra, is the Serpent, the point of whoſe beak touches the crown. At the middle of the ſame place is Ophiuchus, [7*] holding the Serpent in his hand, his

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(4*) Here muſt be ſome error in the text, which runs thus: " Item Aquarii ſupra Equi capitis, Equi ungulæ " attingunt Aquarii genua: Caſſiope media eſt dedicata " Capricorno:" for Vitruvius has ſaid that the Fiſhes are at the back of the Horſe. Aquarius is next to them in the line of the Zodiac, and (as Vitruvius ſays) at the head of the Horſe: alſo the feet of the Horſe are hereafter deſcribed to be under the Swan's tail. It is therefore not poſſible, in this ſituation of things, that the hoofs of the Horſe can touch the knees of Aquarius. Wherefore Philander and Perrault judge that, inſtead of *Aquarii genua*, Aquarius's knees, *Avis pennæ*, the Bird's wings, ſhould be read; and Galiani has changed *ungulæ*, hoofs, to *auriculæ*, ears, which is the more probable correction: although this will not agree with the delineation on the globes. If we might read *gula*, throat, inſtead of *genua*, knees (and it is not very improbable that the word may have been ſo changed by the copyiſt), the reading would then, if joined with Galiani's correction, agree with the uſual appearance on the globes. See the following note.

(5*) " Caſſiope media eſt dedicata Capricorno." Caſſiopeia is at ſo great a diſtance from Capricorn, that it is not likely Caſſiopeia was here meant by the author: Galiani has therefore changed *Caſſiopeiæ* to *Aquarii*: and Perrault has altered the ſenſe of the paſſage by altering the punctuation.

Caſſiope is written in all the manuſcripts I have examined, except one, wherein all the words between *Aquarii* and *Media*, quoted in the preceding note, are omitted, and where conſequently the ſenſe is, that the middle of Aquarius is dedicated to Capricorn, agreeing with the alteration of Galiani.

(6*) "Abea antem volucris cujus penna dextra Cephei " manum attingit, & ſceptrum læva ſupra Caſſiopeia in- " nititur."

Perrault and Galiani tranſlate this paſſage thus: " the " right wing touches the hand and ſceptre of Cepheus, " and the left wing extends to Caſſiopeia." But this cannot be juſt; becauſe Cepheus does not hold the ſceptre in the hand that touches the right wing of the Swan, but in his left hand, which is near Caſſiopeia; nor does the left wing of the Swan extend toward Caſſiopeia, either in the modern globes, or in the antique ſphere preſerved in the Farneſe palace at Rome. The text will very well bear the conſtruction that I, following Barbaro, have given it, which exactly conforms to the repreſentation on the globes. The words " læva ſupra Caſſiopeia innititur" more probably relate to the left hand of Cepheus, than to the left wing of the Swan (although it may be inaccurately expreſſed), becauſe the poſition of Cepheus is not otherwiſe fully deſcribed; and the left wing of the Swan in no globe extends to Caſſiopeia, but to the Horſe's feet: for this reaſon alſo, I believe the words " ſub Avis cauda"— " under the tail of the Bird," following the above quotation, ſhould have been written "ſub Avis penna"—" under " the wing of the Bird;" for the feet of the Horſe are under the left wing of the Swan, not under its tail, in the antient as well as in the modern globes.

(7*) The Serpent-holder, called Serpentarius.

left foot treading on the middle of Scorpio. Not far from the head of Ophiuchus is the head of him who is called the Kneeler[8*]; the tops of their heads are eaſily diſtinguiſhed, being marked by bright ſtars. The foot of the Kneeler is ſupported by the head of the Serpent[9*], that is entwined between him and Arctus, otherwiſe called Septentrio[10*]. At a little diſtance from them is Delphinus[11*]. Lyra is placed oppoſite to the bill of the Swan. The Crown is between the ſhoulder of the Keeper and the Kneeler.

In the northern circle are two Bears, diſpoſed with the back of their ſhoulders to each other, and their breaſts the contrary way; the leſſer is by the Greeks called *Cynoſoura*, and the greater *Helicen:* they are repreſented with their heads looking down from each other, and their tails turned toward the other's head; for of both it may be ſaid, that they are exceedingly conſpicuous by their tails: the Serpent (*Draco*) is extended from that ſtar which is called Polus, and ſhines moſt about the head of the Greater Bear[12*]; for Draco involving the head of that to which it is neareſt, folding once near the head of Cynoſura, and then extending to its feet, bends itſelf, and returns from the head of the Leſſer (Bear) with its beak oppoſed to the Greater (Bear), and ſhewing the right ſide of its head. Upon the tail of the Leſſer (Bear) are the feet of Cepheus; and at the part of the Zenith which is over the head of

(8*) Hercules.

(9*) Draco.

(10*) Urſa Minor, or the Little Bear.

(11*) Philander and Perrault would here alter the text, and inſtead of "parve per eos flectitur Delphinus," read "parvi Equi os flectitur Delphinus:" becauſe Delphinus is at a conſiderable diſtance from the conſtellations here ſpoken of, and is near the little Horſe called Equiniculus.

It appears to me that the correction ſhould be made by reading *Antinous* inſtead of *Delphinus*, ſuppoſing the latter to have been written by miſtake inſtead of the former; for the former well correſponds with the deſcription, being but at a little diſtance from Ophiuchus (of which Vitruvius was ſpeaking), and has not before been mentioned; nor is it at all mentioned by Vitruvius among the conſtellations, unleſs we ſuppoſe it to be here meant; whereas the latter, i. e. Delphinus, he has deſcribed before.

(12*) This is an exceeding intricate and confuſed paſſage, and if the deſcription is not erroneous, it is however very different from that which the modern diſpoſal of the conſtellations will authorize; inſomuch that Galiani has thought proper to reject the common reading, tranſpoſe and change the words, and indeed make a new text of his own. The text, as I find it in the common editions, and in ſeveral manuſcripts, is, "Utrorumque "enim ſuperando eminent in ſummo per caudas eorum "eſſe dicitur; item Serpens eſt porrecta equa ſtella quæ "dicitur Polus, plus elucet circum caput majoris Septen-"trio, namque," &c.

Galiani has altered it to "figurantur utrorumque enim "ſuperando eminent in ſummo equa ſtella quæ dicitur "Polus, plus elucet circum caudam minoris Septentrionis, "per caudas eorum eſſe dicitur item Serpens eſt porrecta, "namque," &c.

As no part of the current text, one word excepted, contradicts the uſual repreſentation of the conſtellations on the globes, I have adhered to it in the tranſlation. I would change only *majoris* for *minoris*; becauſe the ſtars in Draco environ the head of the Leſſer Bear rather than that of the Greater, and the copyiſts may eaſily have miſtaken one of thoſe words for the other. The ſenſe then of the paſſage may be this: "for both are exceedingly "conſpicuous above by their tails; alſo the Serpent is "extended from that ſtar that is called Polus, and ſhines "more about the head of the Leſſer Bear."

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Aries, are the ſtars forming a triangle of equal ſides. In Septentrio Minor and Caſſiopeia there are alſo many ſcattered ſtars.[13*]

Having ſpoken of thoſe conſtellations that are diſpoſed in the heavens to the right of th eaſt, between the Zodiac and the north, I ſhall now deſcribe thoſe that are ſituated by nature in the ſouthern parts, to the left of the eaſt.

C H A P T E R VII.

Of the Conſtellations on the South of the Zodiac.

FIRST, under Capricornus is the ſouthern Fiſh, looking toward the tail of the Whale:[1*] from thence to Sagittarius the place is void. The Altar is under the ſting of Scorpio. Toward Libra and Scorpio are the fore parts of the Centaur, holding in his hands that which aſtronomers call the Beaſt. Near Virgo, Leo, and Cancer, the Hydra winding through a range of ſtars, begirts the place of Cancer, erećting his beak to the Lion; and in the middle of his body ſupporting the Cup: under the hand of Virgo lies its tail, on which is the Crow. Thoſe (ſtars) that are on its ſhoulders are equally bright: under the belly of the Hydra,[2*] at its tail, is the Centaur.

(13*) Galiani has here again altered the text, changing *Caſſiopeia* to *Cephei:* for he having tranſlated *confuſæ* by *communes,* making the text ſay "there are many ſtars com- "mon both to Septentrio Minor and Cepheus," he was obliged to change the name of the conſtellation to make the text agree with his idea.

But as the word *confuſæ* may bear the meaning I have given it, the text may, without any imputation of error, remain unaltered.

(1*) *Cauda proſpiciens Cephea* are the words in the printed editions; but it is univerſally agreed that they are erroneous. Philander, who is followed in this by many others, is of opinion, that the original words were *caudam proſpiciens Ceti,* ſignifying that the fiſh *is looking toward the tail of the Whale:* as is the faćt, according to the modern globes; for Cepheus is at ſo great a diſtance among the northern conſtellations, that it is not probable Vitruvius ſhould allude to him in this place, where he is treating of the ſouthern conſtellations. In ſeveral manuſcripts I find the words are *caudam proſpiciens Cephei;* ſo that very likely the error may be in the laſt word only, which may have been written inſtead of Ceti.

Perrault tranſlates it thus—*and its tail is turned toward Sagittarius;* accepting the word to be Centaurum, inſtead of Cephea, and then underſtanding Sagittarius to be thereby ſignified.

(2*) Perrault ſays it is not eaſy to gueſs whoſe ſhoulders Vitruvius here ſpeaks of; for there are no bright ſtars on the ſhoulders of Virgo, which nevertheleſs ſeem to be thoſe that are deſcribed in the text.

Near the Cup and Leo is the ſhip called Argo, whoſe prow is inviſible; but the maſt, and thoſe parts that are next the ſteerage, are plainly ſeen. The poop of the ſame ſhip joins the point of the Dog's tail. The leſſer Dog, under Gemini, goes before the head of the Hydra; the greater alſo follows the leſſer. Orion is depreſſed tranſverſely under the hoof of Centaurus,[3*] holding it with his left hand, and raiſing the club in his other hand to Gemini.[4*] The head of the Hare, which is at a little diſtance from the Dog, is his footſtool. Under Aries and Piſces lies the Whale, from whoſe creſt narrow ſtreams of ſtars, which the Greeks call *Hermedone*, extend to both the Fiſhes;[5*] and from that great diſtance the ligature of the Fiſhes reaches to the top of the Whale's creſt. Eridanus[6*] flows in the form of a river of ſtars, taking its beginning from the left foot of Orion. The water that is poured from Aquarius runs between the head of the ſouthern Fiſh and the tail of the Whale.

The appearances of the ſtars, figured and formed in the heavens by nature and the Divine Mind, as the philoſopher Democritus believes, I have now explained. But we can only obſerve and diſcover ſuch of them as riſe and ſet; for as Septentrio turns around the cardinal axis (the north pole), without ſetting or paſſing under the earth, ſo around the ſouthern car-

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Galiani reproves Perrault for this idea, and obſerves that Vitruvius is here ſpeaking of the Serpent, i. e. Hydra, not of Virgo; intimating that it is the ſhoulders of the Serpent that Vitruvius means, and to which we muſt look for the *ſtars equally bright* that he mentions. We ſeem deſtined to differ from each other; and in this I muſt differ from both Galiani and Perrault, believing that the ſhoulders of the Crow are here meant: for Vitruvius is ſpeaking of the Crow, which he has juſt before named; and on whoſe ſhoulders there are, in fact, two large ſtars of equal luſtre; whereas there are no ſuch ſtars on the Serpent, or Hydra; nor can the term ſhoulders be properly applied to ſerpents, whoſe bodies are not formed with any part like a ſhoulder. Galiani ſeems to have been aware of this, and has tranſlated *ſcapulas*, *the back*, not *the ſhoulders*, which it properly ſignifies.

(3*) This ſhould undoubtedly be *Taurus*, not *Centaurus*: the ſituation of the two conſtellations plainly prove it to be an error, as is obſerved by all the commentators; for Vitruvius has before mentioned Centaurus to be near Libra and Scorpio; and here he ſays, Orion extends one hand to Gemini; he cannot therefore be near Centaurus.

(4*) "Orion vero tranſverſus eſt ſubjectus preſſus ungula Centauri (Tauri), manu læva tenens clavam alteram "ad Geminos tollens." Theſe words have been generally underſtood to ſignify that Orion is ſituated under the hoofs of the Bull, holding in his left hand a club, and extending the other to Gemini; directly contrary to the uſual repreſentation, in which Orion holds the club in his right hand, extending the ſame to Gemini.

Galiani has therefore inſerted the word *clypeum* between *tenens* and *clavam*, and changed *alteram* to *altera*, thus making the text ſay that Orion holds a ſhield in his left hand. But without altering the text, by making the ſtop after *tenens*, it will agree with the repreſentation on the ancient globe, in which Orion is repreſented holding a mantle in his left hand, cloſe to the hoof of Taurus, and raiſing the club in his other hand to Gemini. Galiani's alteration of the text is therefore unneceſſary. Perrault alſo in his notes has miſtakingly ſaid that Orion holds the club in his left hand, raiſed toward Gemini; whereas he holds the club in his right hand.

(5*) The text has here *ſerpentium*, by which is ſuppoſed to be ſignified the *fiſhes* of which Vitruvius is now ſpeaking.

(6*) So named from the river now called *Po*.

dinal point, which by the inclination of the heavens is situated under the Earth, there are other constellations revolving that are unseen, never rising above the Earth; therefore their appearances, on account of the intervention of the Earth, are unknown. Of this the star Canopus[7*] is a proof, which is not known in these countries, otherwise than by the reports of the merchants who travel to the extreme parts of Egypt, and near to the utmost limits of the Earth.

I have thus treated of the revolutions of the heavens around the Earth, of the twelve signs, and the disposition of the northern and southern constellations, as they are seen; because, by the rotation of the heavens, the contrary course of the Sun through the signs, and the equinoctial shadows of gnomons, the construction of the anallemnas is to be found. As for the other part of astrology, concerning the influence of the twelve signs, the five planets, and the Sun and Moon, upon human life, it is to be left to the Chaldeans, to whom belongs the science of *genethliologia*,[8*] so that they can discover, by the aspects of the stars, both the past and the future. The accounts of their discoveries, which they have left in writing, prove their judgment and ingenuity, and what great men the nation of the Chaldeans has produced. Firstly Berosus, who settled in the island and city of Coos,[9*] and there established a school. Afterward came Antipater and Achinapolus, who left a treatise on the art of Genethliologia, not from the birth, but from the conception. Of natural things, Thales the Milesian, Anaxagoras the Clazomenian, Pythagoras the Samian, Zenophantes the Colophonian, and Democritus the Abderite, have written; and have left their doctrines concerning the causes by which things are governed, and how they produce their effects.

The discoveries of these men were prosecuted by Eudoxus, Eudæmon, Callistus, Melo,[10*] Phillippus, Hipparchus, Aratus, and others, who by astrology, and the use of the parapegmatum,[11*] discovered the rising and setting of the stars, and the indications of the weather; and have left them explained to posterity. The knowledge of such men is revered by mankind; for so great is their judgment, that even, like divinities, they pronounce beforehand the weather that shall afterward happen; wherefore these things ought to be committed to their care and application.

(7*) A large star in the constellation of the Ship. Pliny, b. 2. ch. 70, observes, that it is not seen in Italy, but is just seen at Rhodes.

(8*) The science of foretelling future events in the lives of mankind, and the state of the weather.

(9*) An island in the Archipelago, near Rhodes.

(10*) Perrault writes Euchæmon, Calippus, Meto, which are the names of astronomers mentioned by Ptolemy.

(11*) An astronomical instrument, according to the opinion of some; according to others, a brass table containing astronomical representations.

CHAPTER VIII.

Of Sun-dials, and of the Equinoctial Shadow of Gnomons at Rome and some other Places, with a Description of the Anallemna.

FROM these men we derive the principles of dialling, and are enabled to explain the causes of the decrease of the days in each month, as also the depalations[1*]; for at the time of the equinoxes, when the Sun is passing Aries and Libra, the gnomon having nine parts, its shadow will have eight in the latitude of Rome. At Athens, the gnomon having four parts, the shadow will have three. At Rhodes it is as five to seven.[2*] At Tarentum, as nine to eleven. At Alexandria, as three to five: and so in all other places, according to their situations, the equinoctial shadow of the gnomon is observed to be different. Wherever therefore sun-dials are to be described, the equinoctial shadow, at that place, must be taken.

Fig. LXIX. If it should be the same as at Rome, the shadow having eight of the nine parts of the gnomon, a line is described on a plane, and from the middle, *pros orthas*,[3*] is to be erected that which is called the gnomon; and from the line which is on the plane at the end of the gnomon, a space equal to nine parts is to be measured thereon with the compasses; and in that place, where the mark of the nine parts happens, as at the letter *A*, a center is to be fixed. Then extending the compasses from this center to the line of the plane, where the letter *B* is, a circle is described, which is called the meridian; then of the nine parts which extend from the plane to the center (at the top) of the gnomon, eight are taken, and marked on the line that is in the plane, at letter *C*; this will be the equinoctial shadow of the gnomon: and from the mark at letter *C*, through the center *A*, a line is drawn, which will be the ray of the Sun at the equinoxes. Then from the center, opening the compasses to the line on the plane, set that measure from the plane on the circumferent line, on either

(*1) This word is in some manuscripts written *explanationes*. Some suppose it to signify the method of finding the increase and decrease of the shadow of the gnomon; coming from the word *palor*, to straggle, or wander irregularly: or it may signify the unequal and various divergence of the hour lines.

(2*) Perrault translates it as nine to seven—by mistake, I suppose; for the words are *ad septem Rhodo quinque*.

(3*) At right-angles, or perpendicularly.

ſide, where the letter *E* is on the left, and *I* on the right ſide; and from theſe points a line is drawn through the center that divides the two ſemicircles: this line is by the mathematicians called ***horizon.***

Then taking the fifteenth part of the whole circumference, and placing the central foot of the compaſſes in the circumferent line, at that point in which it is interſected by the line of the equinoctial ray, where the letter *F* is, marks are made to the right and left, where the letters *G* and *H* are, through which, from the center, lines are drawn till they meet the line on the plane, at the letters *T* and *R*, which will repreſent the rays of the ſun, the one at winter, and the other at ſummer.[4*] Oppoſite to the letter *E*, where the circumference is interſected by the line drawn through the center, will be *I*; oppoſite *G* and *H* will be the letters *K* and *L*; oppoſite *C, F*, and *A*, will be the letter *N*: then diametral lines (chords) are drawn from *G* to *L*, and from *H* to *K*, the inferior of which will be the part of ſummer, the ſuperior that of winter.

Theſe chords are divided in the middle at the letters *M* and *O*, where centers are made, through which, from the center *A*, a line is drawn to the extreme circumferent line, where the letters *P* and *Q* are; this line will be at right angles to the equinoctial ray, and is called by the mathematicians ***axon:*** from theſe centers, extending the compaſſes to the extremity of the chords *LG* and *KH*, two ſemicircles are deſcribed, one of which will be for ſummer, and the other for winter. Then in the places where the parallel lines interſect the line which is called horizon, on the right ſide is the letter *S*, and on the left *V*, and from the extremity of the ſemicircle at *G* a line parallel to the axon is drawn to the left ſemicircle, where the letter *H* is, which parallel line is called *lacotomus*[5*]; then the central foot of the compaſſes being applied at that place, where it interſects the equinoctial ray, at the letter *X*, and the other foot extended to that point where the ſummer ray cuts the circumference at the letter *H*, at the center in the equinoctial, with the ſummer interval, the circle *HGC* of the months, which is called *manacus*[6*], is deſcribed: thus we ſhall have the figure of the analemna.

Fig. LXIX.

(4*) This ſuppoſes the inclination of the ecliptic, at the time of Vitruvius, to be 24 degrees, which is the fifteenth part of the whole circumference; that inclination is found to be at this time 23 degrees and ½ nearly, or 23° 28′ ½, which favours the opinion of a gradual diminution in the obliquity of the ecliptic.

(5*) Turnebus reads *leiotomus*, cutting the left; as this line cuts the left or ſummer ray, *AR*.

(6*) By dividing this circle of the months into twelve equal parts, for the ſituation of the Sun in the twelve months of the year, or ſigns of the zodiac, the noon ſhadow of each month may be found; for by marking on the line *HG* the direct diſtances 1. 2. 3. 4. of thoſe diviſions from the equinoctial ray, thoſe marks will re-

This being defcribed and explained, either by the lines of the winter, or the fummer, or the equinoctial, or even of the months, the projection of the hour lines may, from the analemna, be drawn; and many different kinds of dials may be contrived and defcribed by the means of this device: for the effect of the defcriptions and figures of all of them are the fame; the equinoctial, as well as the winter and (fummer) folftitial days, being equally divided into twelve parts.[7*] Thefe figures are not omitted from negligence, but to avoid offending by too much writing. I fhall relate, however, by whom the feveral kinds of dials were invented; for neither can I difcover a new kind, nor will I publifh thofe of others for my own: I fhall therefore mention thofe that have come to our knowledge, and by whom they were invented.

CHAPTER IX.

Of the Conftruction and Ufe of Dials, and of their Invention and Inventors.

THE femicircle excavated in a fquare, undercut to the inclination of the climate, is faid to have been invented by Berofus the Chaldean. The Scaphe, or Hemifphere, by Ariftarchus the Samian, as alfo the Difcus on a plane. The Arachne by Eudoxus the aftronomer, although fome fay by Apollonius. The Plinthium, or Lacunar, one of which is in the Circus Flaminius, by Scopas the Syracufan. The *Pros ta hiftorumena* by Parmenion. The *Pros pan clima* by Theodofius and Andreas. The Pelecinon by Patrocles. The Cone by Dionyfiodorus. The Pharetra and other kinds by Apollonius. Many others alfo, as well as thofe above mentioned, have been invented, as the Gonarch, the Engonatos, the Antiborœum; as likewife the pendent travelling kinds, of which many authors have written, and from whofe

prefent the diftance of the Sun from the equinoctial in each refpective month. Wherefore drawing lines from the top A of the gnomon, through thofe marks, to the plane BT, the length of the noon fhadow in each month will be thereby determined.

(7*) This paffage is a confirmation of the fact, that the antients divided the day, whether long or fhort, into twelve hours, beginning at fun-rife, and ending at funfet, and their dials were formed on that principle. See the following chapter.

books whosoever will may learn the construction, provided they understand the analemma.[1*] There are also water dials, invented by the same authors: the first of this kind was by Ctesibius the Alexandrian; who also explained the nature of the air, and the art of Pneumatics. But it may be worthy of attention to know how these were discovered.

Ctesibius was born at Alexandria; his father was a barber. He being ingenious, and

(1*) The precise form and construction of the dials here mentioned cannot now be, with any certainty, determined or explained. Some conjectures only concerning them may be made from their names. The Scaphe, from the general meaning of the term, we may conclude was a hemisphere of the concave kind. The Discus, for the same reason, was probably a dial formed as a horizontal circular plane. The Arachne, like a spider's web. The *Plinthium* is in some manuscripts written *Pantium*; and *Lacunar* Baldus would alter to *Laterem*, as more suitable in its meaning to *Plinthium*, expressing a cubical or solid body, which is supposed to be the form of the dial here mentioned; whereas the term *Lacunar* is expressive of a hollow, or excavation. The *Pros pan clima* is a dial so constructed as to suit all climates: but what sort the *Pros ta historumena* signifies, is not agreed on; some suppose that the term expresses a kind of dial made for all parts of the earth that were known, or mentioned in historical or geographical descriptions. The Pelecinon, or Ax—and the Pharetra, or quiver, were probably dials of a form like those instruments. The Gonarch and Engonatus, to guess from the meaning of the words, may have been of the angular kind. And the Antiboraum an antartic or southern dial, or one disposed to the south.

In Poleni's *Exercitationes Vitruvianæ* is an attempt to discover the Hemicycle of Berosus, by Jacob Ziegler; and in the Giornale de' Litterati, for the year 1746, is also a comment on an antient dial found at Frascati in Italy, by P. Boscovick, who supposes it to be that called the Hemicycle of Berosus. Mr. Stuart likewise found at Athens an antient sun-dial that so well agrees with the short description Vitruvius gives of this Hemicycle, that it is not improbable it may be the same. It is represented at *Fig. LXX. ABCD* is the front elevation, *AMNE* the section through the middle, and *AOPB* the upper surface, or top. The dial stands on the southern side of the rock of the Acropolis, and is a little disjointed from the base on which it was originally fixed.

Mr. Stuart has given an engraving of it in the Vignette of the fourth chapter of his second volume of Athenian Antiquities, but without the figures. I have therefore inserted it here with the figures, in order to preserve this curious relick of antiquity.—The plane *ABCD* is supposed to be parallel to that of the equator; its inclination from the perpendicular is 36° 37′, by Mr. Stuart's measurement: although according to Vitruvius (who in the foregoing chapter says the equinoctial shadow at Athens is to the gnomon as 3 to 4) it should be 36° 43′. This difference, Mr. Stuart supposed, might be owing to the upper surface of the dial being so much injured by the weather, as made it impossible to measure it accurately. The line *EF* inclines about 8° 45′ from the perpendicular. The hour lines are all equidistant. The line *GG* shews the winter solstice, *HH* the equinoctial, and *AE* the summer solstice. The gnomon, or style, was probably a horizontal bar, fixed on the top, and of such a length that the end of its shadow reached to the line *AE* at the summer solstice, and to the line *GG* at the winter solstice. The measures are in English feet and inches; and all that were in Mr. Stuart's sketch are here inserted.—Another antient dial (No. 2, *Fig. LXX.*), formed on the same principle, but of a smaller size, is at the earl of Besborough's at Roehampton, and is a very valuable piece of antiquity. The inclination of the plane *AB* (supposed to be that of the equator) is about 31 degrees from the perpendicular, which is the latitude of Alexandria in Egypt; wherefore it is probable this dial was made for that antient city. The centre *D*, from whence the hour lines issue, is a little above the present top of the stone; probably so much as was equal to the thickness of the gnomon, which, by the holes yet remaining, seems to have been there fixed. The intervals *e, f, g*, of the hour lines at either extremity, are less than those in the middle at *i*: but this may be owing to the figure of the excavation not being truly semicircular; for, had it been so formed, I find by trial that the intervals would have been all equal. This however is not the case in the Athenian dial; for the intervals therein are all equal, although the curve of the excavation appears to be parabolic.

withal exceedingly induſtrious, was called "the delighter in works of art." Endeavouring to ſuſpend a ſpeculum in his father's ſhop, ſo that it ſhould be drawn up and down by a ſecret line and weight, he contrived it thus: He fixed a wooden channel under the beam, and placed there a pulley; through the channel he paſſed a cord to the angle (of the room), where he made tubes, down which he let a leaden ball with a ſtring. It happened that the weight deſcending into the narrow tubes, and compreſſing the incloſed air, violently forced it through the ſeveral apertures into the open air, and thereby produced diſtinct ſounds. When therefore Cteſibius obſerved that ſounds were produced from the compreſſion and concuſſion of the air, he firſt made uſe of that principle in contriving hydraulic organs; alſo water-forcers, automatons, lever and turning machines, and many others of the entertaining kind: and from this likewiſe he deviſed the conſtruction of water dials.

And firſt he fixed a tube made of gold, or of a gem perforated; becauſe theſe neither wear by the friction of the water, nor produce dirt to cauſe obſtructions. The water flowing equally through this tube, raiſes an inverted bowl, called by the artificers the *phellos* (the cork), or the *tympanum*; to which are connected a ruler, and wheels, with teeth made exactly equal. Theſe teeth impelling others, cauſe regular revolutions and motions: for other rulers, and other wheels, in the ſame manner indented, are by this ſingle motion actuated ſo as to produce various rotations and movements; by which images are put in motion; metæ are turned round; ſtones, or ovæ[2*], are rejected; trumpets are ſounded; and other devices diſplayed. In this alſo, either on columns or pilaſters, the hours are marked; which an image riſing from the bottom ſhews with a wand, during the whole day, the ſhortneſs or length of which is daily and monthly adjuſted by adding or removing of wedges.

The ſtoppers of the water, which are to regulate its motion, are thus formed: Two metæ, one convex, the other concave, are by means of a turning machine made ſo exactly, that one may juſt go into the other. The regulator, by drawing theſe apart, or preſſing them together, increaſes or abates the influx of water in the veſſel. Upon this principle the water dials for winter uſe are conſtructed. If the cloſing or removing of the wedges ſhould not correſpond with the decreaſe or increaſe of the days (for the wedges are oftentimes made imperfect), it muſt be thus ordered: On the column, the hours taken from the analemma are

(2*) This word is written *tonæ* in the printed editions, but is by ſeveral of the commentators corrected to *ovæ*, as it is alſo written in many manuſcripts; I have found it ſo in four out of five that I have examined: it is ſuppoſed to ſignify ſmall ſtones of an oval form, as *calculi* may have been the common term to ſignify ſuch as were globular, called by us *marbles*. At the 14th chapter of the following book, Vitruvius uſes the words *calculi rotundi*. Theſe ſtones were probably uſed to denote the hour of the day, by being thrown from the dial into a vaſe or bell.

to be tranſverſely deſcribed, and the lines of the months marked; the column alſo is to be made verſatile, ſo that by always turning the column to the wand of the image, which wand, as the image aſcends, ſhews the hours, it may determine, according to the reſpective months, the ſhortneſs and length of the hours.

Other kinds of water dials, which are called *anaporica*, are alſo made in this manner: The hours taken from the analemna are marked on rods of braſs, diſpoſed in the front from the center. On theſe are circumſcribed circles, bounding the ſpaces of the months. Behind the rods, a tympanum (a wheel) is placed, in which is deſcribed and painted the circle of the Zodiac, with the figures of the twelve ſigns; formed from the center, according to the ſpace of each ſign, one being greater, another leſs. Behind and to the middle part of the tympanum is fixed a verſatile axis; and about this axis a pliable braſs chain is wound, to one end of which hangs a phellos or tympanum, that is raiſed by the water; and to the other end a counterpoiſe of ſand, equal in weight to the phellos. Thus, as much as the phellos is raiſed by the water, ſo much the weight of ſand deſcending turns the axis, and the axis the tympanum; the rotation of which tympanum cauſes ſometimes the greater part of the circle of the Zodiac, at other times the leſſer, to be in motion, thus adjuſting the length of the hours according to the ſeaſons. In the ſeveral ſigns are made holes, correſponding to the number of days in the month, by which the bulla (index), that in dials repreſents the image of the Sun, ſhews the lengths of the hours, and moving from hole to hole, completes its courſe in the paſſing month. Thus as the Sun, traverſing the circuit of the ſigns, lengthens and ſhortens the days and hours, ſo the bulla in dials, by its point paſſing contrary to the rotation of the middle of the tympanum, if daily transferred, ſhews the hours and days within the repreſented limits of the months, ſometimes by a larger, and ſometimes by a ſmaller ſpace.

The management of the water, and the regulation of it for the operation, is done thus: Behind the front of the dial, inwardly, is placed a caſtellum (a ciſtern), into which a pipe conveys the water, and at the bottom is a cavity: to this is fixed a braſs tympanum, having a hole, through which the water from the caſtellum flows into it. In this a leſſer tympanum is included, with the joints exactly turned, maſculine and feminine, united together; ſo that the leſſer tympanum may, like a ſtopple, fit cloſely in the greater, and yet be turned eaſily. On the lip of the greater tympanum are made 355 points at equal diſtances; and on the circumference of the leſſer orbicule (or tympanum) is a fixed tongue, whoſe tip directs to the place of the points. Then in this orbicule is a hole juſtly proportioned, which the water in the tympanum runs through, and ſerves the work.

The repreſentations of the celeſtial ſigns are deſcribed on the lip of the greater tympanum, which is immoveable; and at the top is the ſign of Cancer: perpendicular thereto, at the

bottom, Capricorn; on the right of the ſpectator, Libra; on the left, Aries: and the other ſigns are diſpoſed between them, in the order they are ſeen in the heavens. Then when the Sun is in the orbicule of Capricorn,[4*] the tongue being at the part of Capricorn in the greater tympanum, daily touching the ſeveral points, having perpendicularly the great weight of the running water; this (water) forces with velocity through the hole of the orbicule into the vaſe then receiving it: being therefore ſooner filled, it diminiſhes and contracts the lengths of the days and hours. When by the daily rotation the tongue enters into Aquarius of the greater[5*] tympanum, the holes entirely deſcend (depart) from the perpendicular; and the violent courſe of the water being reſtrained, the orifice diſcharges more ſlowly: ſo that, as the vaſe receives the water leſs rapidly, it increaſes the lengths of the hours. From the points of Aquarius and of Piſces, when, in aſcending the degrees, the hole of the orbicule is an eighth part in Aries, the water then flowing moderately to the orifice, produces the equinoctial hours.

From Aries, paſſing through the places of Taurus and Gemini,[6*] to the higheſt point, the eighth part of Cancer, the hole or tympanum continuing to revolve, and arriving at the ſum-

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(4*) "Igitur cum ſol fuerit in *Capricorni orbiculo*, "lingula in majoris tympani parte," is as it is written in the editions of the text, which bears the tranſlation I have given. But I believe it ſhould be *Capricorno*, *orbiculi*, &c. interchanging the terminations of the words *Capricorni* and *orbiculo*, and placing the comma after the former; then, inſtead of the preſent reading in the tranſlation, it will be—"when the Sun is in Capricorn, the "tongue of the orbicule, &c." For Vitruvius has before called the leſſer tympanum, which has the tongue, by the name of *orbicule*: and it ſeems more probable that the ſame appellation is here applied to the ſame thing, than that it ſhould be given to the ſign of Capricorn, which is but a portion of a circle, and therefore not ſuited to the term, *orbicule* implying an entire circle.

(5*) In all the tranſlations, the word *majoris* in this place is rendered *minoris*; but unneceſſarily, as I believe. The tranſlators allege that "Vitruvius has before ſaid "that the greater tympanum was immoveable, and yet "that it is ſpoken of as moving." This ſeems to me not to be the fact, and that the paſſage may be underſtood in the manner I have rendered it.

The following part of this paſſage is probably alſo miſconſtrued: "Cuncta deſcendunt foramina perpendiculo, "& aquæ vehementi curſu cogitur tardius emittere ſalientem." This is made to ſignify (except in Perault's free tranſlation), "all the holes fall perpendicularly, and "by the violent courſe of the water the pipe diſcharges "more ſlowly;" which is a ſenſe directly contrary to the effect of the mechaniſm, as deſcribed in the other ſentences: for they expreſs that the more violent courſe of the water cauſes the pipe to diſcharge faſter.

Cogitur is here I think to be underſtood in the ſenſe of checking or reſtraining the force of the water; and in that ſenſe the paſſage will agree with the context, and ſignify that the courſe of the water is made leſs violent by the place of the hole being changed; and for that reaſon the orifice diſcharges ſlower.

The word *deſcendunt* however may be an error, and written inſtead of *diſcedunt*, as Philander ſuggeſts; for the holes cannot be ſaid to deſcend, the tongue and hole of the leſſer tympanum being already at the loweſt point, and in moving from thence muſt aſcend, as Vitruvius expreſſes in the next ſentence (*gradibus ſcandens*): but the holes by that motion may be ſaid to *depart* from being perpendicular to each other; and this the word *diſcedunt* will ſignify.

(6*) It may be uſeful to mention as a caution, that in Perault's tranſlation all the words relative to the equinox of Aries, and the ſigns Taurus and Gemini, are omitted.

mit, the power relents, and flowing more flowly, enlarges the fpaces, and produces in the fign of Cancer the folftitial hours. Defcending from Cancer, through Leo and Virgo, to the point at the eighth part of Libra, it gradually leffens the times, and contracts the hours; and thus arriving at the points of Libra, caufes again the equinoctial hours. The hole ftill paffing downward through the tracts of Scorpio and Sagittarius, returns again to the eighth part of Capricorn, when, by the celerity of the ftream, the fhortnefs of the winter hours is produced.

The apparatus and methods ufed in the conftruction of dials, I have defcribed as well as I have been able. It now remains to treat of machines, and their principles; of thefe therefore, that the entire fyftem of Architecture may be completed, I fhall write in the following book.

END OF THE NINTH BOOK.

THE

ARCHITECTURE

OF

M · VITRUVIUS · POLLIO.

BOOK THE TENTH.

PROEM.

IN that large and noble city of the Greeks, Ephesus, an old law, it is said, was established by the antients; of which the conditions were severe, but not unjust: for the architect, when he received the charge of a public building, was obliged to deliver an estimate of the expence, and assign over his goods to the magistrates, till the work should be completed. This done, when the expence agreed with the estimate, he was rewarded with decrees and honours; also, if no greater sum than a fourth part more was expended in the work, it was added to the estimate, and supplied by the public; nor was any penalty incurred: but when more than a fourth was expended, his goods were seized, to make up the sum. I wish, to the immortal Gods, that this law were established among the Roman people, not only in public, but also in private edifices, that the unskilful might not commit impositions with impunity: for those only who are skilled in the knowledge of the art, and are without doubt really professors of architecture, should be employed; nor be suffered to lead fathers of families into profuse expences, but be driven from among the good: and that architects themselves, from the fear of losing their property, might be obliged to be more careful in making their estimates; so that proprietors might, with what they had prepared, or a little more, discharge the cost of the building. For those who can provide four hundred, will cheerfully add

another hundred: but if they be encumbered with the addition of one half, or more, they lofe hopes; and becoming difpirited with the expence, and lofs of their property, are forced to defift.[1*]

Nor does this happen in buildings only, but alfo in the works for the fhows that are given by the magiftrates, of gladiators in the forum, and of plays in the theatres: in which neither hindrances nor delays can be allowed for, but they muft neceffarily be finifhed within the limited time. Such are the feats[2*] of the fpectatory; the extenfion of the vela; and all thofe things which, according to the ufage of theatres, are prepared for the machinery of the public fpectacles. In thefe works, great judgment and ingenuity are required; for they cannot be accomplifhed without mechanical inventions, and the knowledge of various fciences. As thefe therefore are eftablifhed, and in ufe, it feems not foreign to the purpofe, before other fubjects are begun, to explain accurately their principles.

Since therefore neither law nor cuftom enforces this obligation, and the prætors and ediles muft every year prepare machines for the games; it feems to me, O Emperor, not improper, as I have in the former books treated of buildings, to treat in this, which finifhes the whole work, the precepts and eftablifhed principles of machines.

(1*) Galiani obferves that, if there was occafion to wifh for fuch a law at Rome in Vitruvius's time, much more fhould they now wifh for fuch a one at Naples; where every one who builds finds himfelf cheated, and the eftimate exceeded not only by a quarter or half, but by double or quadruple. This feems to be a very general cafe; it is indeed highly probable that a building will in all cafes exceed the eftimate previoufly made of it, although done with all poffible exactnefs and circumfpection; for it may not be poffible to forefee every circumftance that will occafion expence: and wherever a great number of men are employed, accidents, miftakes, and inadvertences, will happen, which it is impoffible to forefee, or prevent: and fometimes even the alterations of the inclination in the proprietor may operate to occafion an increafe of expence beyond what was firft calculated; as well as difhonefty, and a predeterminate intention to deceive, in the workmen.

(2*) At note 8, ch. 6, b. 5, it is remarked, that Vitruvius there alluded to fome kind of coverings that were laid upon the ftone degrees of the theatres, at the times the games were performing. The word *fedes*, feats, in this paffage, I fuppofe to fignify thofe coverings which were of boards, mattraffes, &c. and were probably provided, or at leaft fixed upon the degrees, by the workmen (according to an eftimate) every time the theatre was ufed. That fome temporary kind of feats are here meant, is evident from their being mentioned with the *vela*, which was a temporary awning fpread over the *fpectaculum* (or part where the fpectators fat), as a fhelter from the weather during the performance. Perault and Galiani, prepoffeffed with the opinion that Vitruvius lived before the time fuch coverings became in ufe, endeavour to reconcile this paffage to their ideas. Perault, however, admits that fome temporary feats muft be here meant by the words *fedes fpectaculorum*. Galiani fuppofes they fignify an entire temporary wooden theatre, or the degrees of one, built in fome forum, &c.; an idea which the fenfe and purport of the paffage will not admit: for Vitruvius oppofes them to buildings, by faying falfe eftimates are given in thofe things as well as in buildings.

On the firft difcovery of the theatre of Herculaneum in Italy, the degrees were found to be covered with wood, according to the account of the Marquis di Venuti, who fays the faid degrees appeared like a wooden ftaircafe, but too high for ftairs.

CHAPTER I.

Of Machines and Inftruments, and of their Origin and Ufe.

A MACHINE is a compofition of timber, its ufe being chiefly for moving of great weights.[1*] It is moved by the fkilful rotation of circles, which the Greeks call *cyclicen cinefin*. One kind of thefe is called *fcanforium*, which by the Greeks is called *acrobaticon*; another, *fpiritale*, which they call *pneumaticon*; and a third, *tractorium*, which the Greeks call *banaufon*.

The Scanforia are machines fo contrived, that beams being erected, and tranfverfe pieces bound thereto, they may without danger be afcended, for the purpofe of reconnoitring.[2*]

The Spiritalia are thofe in which the preffure of the air gives the impulfe, and by which motions and organical founds are produced. The Tractoria are thofe by means of which weights are drawn forward, or are raifed aloft. The practice of the Scanforia depends not fo much on art as on courage. Thefe machines are fecured with chains, tranfverfes, platted ligatures, and fupporting props. In thofe in which the power of the air is ufed, the effect is

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(1*) This is, as Perault obferves, an imperfect definition of a machine, which may undoubtedly be made of any materials. But it is to be underftood as an explanation of what Vitruvius means by the word *machine*, and allowance made for the ideas of the times.

(2*) The meaning of the words *ad apparatus fpectationem*, which I have tranflated for the purpofe of reconnoitring, is contefted. Barbaro, Perrault, and I, agree in opinion: but Galiani thinks the words fignify, that thefe machines were to raife men aloft, for the purpofe of viewing the public games and fpectacles; which opinion feems improbable, as the antients had regular theatres for that purpofe; and it is not likely that a number of people, affembled on thofe occafions, fhould be raifed on machines, that (Vitruvius fays) were only fecured with chains and ropes: thefe indeed would be fufficient to fupport one or two foldiers to reconnoitre and look over the walls of a befieged town. At the 19th chapter of this book, Vitruvius mentions the afcending machine (*afcendentem machinam*) as one of thofe machines of war that raifed men from the ground to the top of the enemies walls. And, at the 22d chapter, fpies are called *fpeculatores—cum a fpeculatoribus*.

Vegetius alfo, l. iv. c. 21, defcribes a machine by the name of *tolleno*, for a fimilar purpofe, nearly agreeing with this in defcription. Apollodorus and Heron, treating of machines, defcribe that ufed for overlooking the enemies walls, which exactly anfwers to the idea Vitruvius gives.

It appears therefore probable that the *fcanforia* were thofe machines that were ufed for reconnoitring befieged towns; and not for the purpofe of viewing the public fhows and fpectacles, as Galiani imagines.

obtained by the ſubtilties of art. The Tractoria, however, have greater and more extenſive uſes; and if managed with ſkill have the greateſt power. Of theſe, ſome are moved mechanically and others organically.

Between machines and inſtruments (organa) there ſeems to be this difference: machines are made to produce their effect by means of many operations, or by greater forces, like the baliſtæ, and ſcrewing preſſes; whereas inſtruments, if judiciouſly managed, with one operation perform the intention, as in the ſcorpions, or the rotations of aniſocycles.[3*] Both inſtruments and machines are uſeful, and without them no work can be expedited. All mechaniſm is derived from Nature, and eſtabliſhed by that governeſs and miſtreſs of the world, in the revolutions thereof. This we may chiefly obſerve and admire in the continual courſe of the Sun, of the Moon, and alſo of the five planets; which unleſs they were mechanically moved around, we ſhould neither have the earth illuminated, nor the fruits thereof ripened. The antients obſerving this, took example from Nature, and imitating thoſe divine works, contrived the conveniences of life; ſome therefore invented machines, and others inſtruments, that by their action works might be more expeditiouſly performed: and as theſe were found to be uſeful, by ſtudy, practice, and precepts they were gradually improved.

Let us reflect on the firſt invention neceſſary to life—clothing; how from the working the organical looms, which connect the warp with the woof, the body is not only preſerved by the covering thereby made, but alſo is ornamented, and even acquires additional dignity. We ſhould not have ſuch plenty of food, unleſs the yoke and the plough for oxen, and other beaſts, had been invented; and without the aſſiſtance of windlaſſes, preſſes, and levers, we could not enjoy the ſweetneſs of oil, nor the fruit of the vine; neither could theſe be conveyed, unleſs the machines of carts and waggons for land, and boats for water carriage, had been invented. Scales alſo, and balances, for the examination of the weights of bodies, ſecure us from injuſtice in the tranſactions of life.

There are innumerable machines of which it is unneceſſary to diſcourſe; becauſe they are

(3*) What inſtruments or machines are meant by aniſocycles, is not known: the literal ſignification of the word is, unequal circles; whence they are generally ſuppoſed to be machines of the cochlea or ſpiral form, perhaps ſcrews. The diſtinction that Vitruvius makes between machines and organs, is here expreſſed by machines and inſtruments; the word *organ* in our language having become chiefly applicable to the muſical wind inſtrument of that name. *Utenſil* I once thought would ſuit the deſcription, but I found it would not ſo well agree with the term in other paſſages, as in the 9th chapter following.

daily at hand; ſuch are the Smith's Bellows, the Rotæ, Rhedæ, Ciſiæ, Torni[4*], and others that are in common uſe: we ſhall therefore begin to explain thoſe only which rarely come to hand, that they alſo may be known.

CHAPTER II.

Of Tractorial Machines.

Fig. LXXI. WE will firſt begin with thoſe that are prepared for the erection of temples and public edifices, which are thus made: Three beams (*AAA*), proportional to the greatneſs of the weight to be raiſed, are provided; at the top they are joined together with a *fibula*[1*] (*B*), and are erected diverging at the bottom; being by ropes tied at the top, and diſpoſed about, kept upright. A *trochlea*[2*] (*C*), which ſome call *rechamus*, is faſtened to the top; in the trochlea are two pulleys[3*] (*a a*) turning on an axis: through the upper pulley the drawing rope is paſſed; then it deſcends, and paſſes round the under pulley of an inferior trochlea, and returns to the under pulley of the ſuperior trochlea; when it deſcends to the inferior, and in a hole therein the end of the rope is fixed; the other end of the rope paſſes to the bottom of the machine. On the hinder face of the beams, at the place where they diverge, are fixed *chelons*[4*] (*E E*), in which the ends of a windlaſs (*F*) are inſerted, ſo as to turn eaſily on its axis:

(4*) Theſe are alſo the names of machines with which we are now unacquainted, wherefore I have given the originals without attempting to tranſlate them. Rotæ are ſuppoſed to be ſome kind of machines acting chiefly by wheels. Rhedæ and Ciſiæ were a ſort of vehicles or chariots; the latter are ſaid to have had no more than two wheels. The Torni were turners wheels or lathes.

(1*) *Fibula* probably here ſignifies a bolt, pin, or ſcrew (*B*), put through the upper ends of the three beams.

(2*) A *trochlea* is that which we call a block or ſheaf, which is the caſe containing a ſet of pulleys.

(3*) It appears by the deſcription that the pulleys were placed under one another in the antient ſheafs; in ours they are generally placed by the ſide of each other, and turn on one and the ſame axis. It is to be obſerved, that this machine is repreſented by *Fig. LXXI.* in the ſtate of being raiſed, as deſcribed in the next chapter.

(4*) We have no term to expreſs the *chelons*, which are the ſockets or collars (*E*) fixed to the beams to receive the axis of the windlaſs. I find this word written *belonia*, *chelonia*, and *celonia*, in different manuſcripts.

the windlaſs has two holes near the ends, adjuſted to receive the levers (*G G*). To the lower rechamus alſo iron *forceps* (*H*, *Fig. LXXV.*) are faſtened[5*], the teeth of which are fitted to holes in the ſtone: then when the end of the rope is fixed to the windlaſs, and the levers turn it, the rope winding itſelf round the windlaſs is diſtended, and thus raiſes the weight to the height and place of the work.

CHAPTER III.

Of the different Names of theſe Machines, and how they are erected.[1*]

A MACHINE on this principle, which is worked by three pulleys, is called *triſpaſtos*; but when there are two pulleys turning in the lower trochlea, and three in the higher, it is called *pentaſpaſton*. If machines are to be prepared for greater weights, beams of greater lengths and thickneſſes muſt be uſed; the fibula at the top, and the windlaſs at the bottom, being applied in the ſame manner.

(5*) The text has *forſices*; but Philander thinks it ſhould be read *forcipes*, ſignifying ſome machine of the pincer kind, which it is ſuppoſed the antients uſed to take hold of the ſtone. The inſtrument now generally uſed for that purpoſe is not of the forceps or pincer kind, but of a conſtruction more ſecure and more convenient; it is called by us *louis*, by the French *louve*, and is repreſented by *Fig. LXXII.* and *Fig. LXXIII.*

Another kind of theſe inſtruments, uſed in France, ſeems to be yet more ſimple and expeditious, but not quite ſo ſafe, in caſe the rope ſhould by any accident be ſlackened: it is repreſented by *Fig. LXXIV.* Piraneſi, in the third volume of his Antichita Romana, aſſerts that he found in ſome of the antient buildings ſtones that had holes cut in their upper ſurfaces, in ſuch a form as to ſuit the dovetail ſhape of the modern louis; and from thence ſuppoſes that the antients were acquainted with that machine.

(1*) Galiani, who has altered the titles of many of the chapters, has changed the title of this to "De alia machina "tractoria"—"another drawing machine," which appears to be an erroneous alteration; for Vitruvius is evidently not treating of another, but of the ſame kind of machines that he ſpoke of in the preceding chapter: he here only mentions their names, and how they are elevated. Galiani has probably been led into this miſtake by the erroneous ſeparation of this from the foregoing chapter.

Fig. LXXI. These being explained, the ropes called *antarii* [2*] are loosely placed in the fore part; the *retinacula* [3*] (*I*) are disposed at length over the shoulders of the machine, and, if there be no place where they can be fastened, posts (*K*) are put slanting into the ground, and well rammed around, to which the ropes are tied. A trochlea (*C*) is then bound with ropes to the head of the machine, and therefrom a rope is continued to a post (*K*), where it is put round the pulley of a trochlea (*L*) that is tied to the post, and from thence is referred to that trochlea (*C*) which is at the head of the machine; where, winding round the pulley, the rope descends from the top, and passes to the windlass (*F*) at the bottom of the machine, and is there fastened. The windlass being then forced round by the levers, the machine without any danger raises itself. Thus by the disposition of the ropes, and joining the retinacula to the posts, the machine is in a proper manner adjusted; the trochlea and drawing rope being applied as above written.

CHAPTER IV.

Of a similar Machine of greater Power.

Fig. LXXV. BUT if a larger and more ponderous mass be to be raised, windlasses are not to be trusted; but in the same manner as the windlass is retained in the chelons, so is an axis to be inserted, having in the middle a large tympanum (*M*), which some call *rota*, but which the Greeks call *amphireusin*, and others *peritrochon*.

In these machines the trochleas are not prepared in the same, but in a different manner, having at the bottom and at the top a double row of pulleys: the drawing rope being passed through the hole of the lower trochlea (*L*), so that the two ends of the rope, when extended,

(2*) The commentators are not agreed on the meaning of the word *antarii*, or what ropes it signifies: some suppose it to be an error, and should be written *ductarii*; to which Galiani has altered it, thereby making it signify the ropes that draw up the weight, which it probably does. But I find it written *antarii* in five manuscripts that I have consulted: I have therefore retained it, as it may have been the common name of those ropes at that time.

(3*) The *retinacula* are those ropes which are used to sustain the machine erect, and prevent its being forced from its position by the weights it draws or raises; these ropes extend in various directions from the head of the machine, and are fastened at the other end to stakes driven into the ground, or to any other object that may happen to be properly situated, and be sufficient for that purpose.

may be equal, it is there to be bound and connected with cords to the lower trochlea; and both parts of the rope ſo faſtened, that neither the right nor the left part may eſcape. Then the ends of the rope are carried to the outward ſide of the higher trochlea (*c*), and thrown round the under pulleys (*d*): returning then to the bottom, they are paſſed round the pulleys of the lower trochlea (*L*) on the inner ſide, and thence carried on the right and left to the top of the upper pulleys (*e*) of the higher trochlea; and, being thrown over from the outer ſide, are referred to the axis on the right and left of the tympanum, where they are ſecurely fixed.

Then winding another rope round the tympanum, it is continued to the capſtan (*N*), which by its motion turning the tympanum and axis, the ropes that are faſtened to the axis are by theſe means extended; and thus the weight (*O*) is gently, and without danger, elevated. But if a larger tympanum be placed either in the middle or at one end, without having a capſtan, the work may be more expeditiouſly performed, by the walking of men therein.

CHAPTER V.

Of another Kind of Tractorial Machine.

Fig. LXXVI. THERE is another kind of machine, ingenious enough, and expeditious in uſe; but it cannot be truſted in the work, except to thoſe who are ſkilful. It is a beam (*A*) that is erected and held by retinacula (*I*) four different ways: below the retinacula two chelons (*E*) are fixed; a trochlea (*C*) is bound with ropes upon the chelons; under the trochlea is put a ruler (*D*) about two feet long, ſix digits broad, and four thick.[1*] The trochleas have three rows of pulleys in breadth[2*]; ſo that three drawing ropes are bound to the top of the machine: theſe are carried to the lower trochlea (*L*), and thrown over its upper pulleys from the inner ſide; then referred to the higher trochlea (*C*), and thrown round its under pulleys from the outer to the inner ſide, when they deſcend to the lower (trochlea); and paſſing

(1*) The uſe of this *ruler* is not explained by Vitruvius; but it probably is to ſupport the upper trochlea at a little diſtance from the *beam*, ſo as to admit the pulleys to revolve eaſily, and alſo to give room for the drawing ropes to paſs between the trochlea and the beam.

(2*) It appears by the deſcription that the trochleas of this machine have three rows of pulleys in height, as well as three in breadth.

round the fecond range of pulleys from the inner to the outer fide, they are carried to the fecond range of pulleys of the higher (trochlea), which paffing over, they return to the loweft: from the loweft they are carried to the upper; and paffing round the uppermoft (pulleys), return to the bottom of the machine.

At the root of the machine is placed a third trochlea (*P*), which is called by the Greeks *epagonta*; by us, *artemon*. This trochlea is bound to the foot of the machine, and has three pulleys, around which the ropes paffing, are conveyed thence to the men (*R*) who are to pull them; and fo by the power of three rows of men, the weight is, without a capftan, quickly raifed to the top. This kind of machine is called *polyfpafton*[3*], becaufe it has many pulleys, which produce facility and expedition. The ufing of one beam has this convenience, that the load may be put as much as you will either before or declining to the right or left fide.

All the machines before defcribed, are adapted not only to thefe purpofes, but alfo to the loading and unloading of fhips; fome being difpofed erect, others horizontally in verfatile *carchefia*[4*]; fo likewife, without erecting beams, by a fimilar management of ropes and trochleas on the plain ground, fhips are drawn afhore.

(3*) Our workmen alfo fometimes make ufe of a machine fimilar to this, being a long *beam* fixed at the bottom in a wheel, as its bafe; and having fheaves of pulleys at the top, by which ftones or timbers are raifed to the height of the work.

As Perrault's figures of thefe machines appear to be accurate and intelligibly drawn, I have made ufe of them fo far as they accord with my ideas, altering them only where I imagined they were mifconceived or erroneous.

(4*) Vitruvius fpeaks of the *charchefium*, at the laft chapter of this book, as being a very fimple machine, and ufually made by the foldiers themfelves. Some part at the top of a fhip's maft was called by the fame appellation, as was alfo a particular kind of cup. It is fuppofed to have been an upright beam, with another lying horizontally acrofs the top, and moveable upon a hinge upward and downward, as well as having a horizontal motion around; by thefe motions therefore it could raife things from the ground, and then convey them to their intended fituation.

The French *grue* is a machine of this kind, and is very ferviceable in building, but is not ufed in this country. It may not therefore be ufelefs to defcribe it, and give a reprefentation thereof. *A B*, *Fig. LXXVII.* is a poft fupported by the ftruts and frame *C*; on the pivot *A* refts a long beam *D D*, fixed to the timbers *E E* and *F F*, and fupported from them obliquely by braces *G G*. In the timbers *E E* and *F F* (each of which confifts of two pieces bolted together laterally) are cut round holes at *H H*, large enough to admit the poft *A B*, which is cut cylindrically in thofe places: by thefe means the whole triangular frame *F D F* refts, and may be turned upon the pivot *A*, and is preferved in its pofition by the timbers *E E* and *F F*, embracing the poft at *HH*. From the timber *F F* hangs a cylindric wheel *I*, large and broad enough for two or three men to walk in it: around the axis *K* of which is wound a rope, which paffing through the timber *F F* to a pulley at the end of the timber *E*, is carried to the upper end of the long beam *D D*; where paffing round a pulley *D*, it defcends, and is faftened to the weight *L* to be raifed. The men then, by walking in the wheel *I*, turn it, and wind the rope round the axis *K*, thereby raifing the weight; which, when arrived at the height required, is, by turning the machine on the pivot *A*, conveyed to its place in the work.

Perrault has, in his tranflation of Vitruvius, given an account of a machine to raife weights, that acts upon the principle of the *roller*, having (as he miftakingly afferts) no friction: a model of it is kept in the cabinet of the King of France. It confifts of a long column [illegible], *Fig. LXXVIII.* refting at bottom on a pivot *A*, and fup-

CHAPTER VI.

Of Ctesiphon's ingenious Manner of conveying heavy Weights.

Fig. LXXIX. IT is not foreign to the purpose to explain the ingenious contrivance of Ctesiphon, who, when he wanted to convey the shafts of columns from the quarry to the Temple of Diana at Ephesus, being unwilling, on account of the greatness of the weight, and the softness of the fields in the way, to trust to carriages, or hazard the sinking of the wheels, contrived thus: He combined and united four *triental*[1*] pieces of timber (*ABCD*): two (*AD*) interposed transversely to two (*BC*) equal to the length of the shaft (of the column): at the ends (*AD*) of the (said) shafts he inserted iron *chodaces*, like dovetails,

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ported upright by the frame and braces *CCC*, and by passing through a hole at *D*. On the top of the column is fixed a transverse timber *FE*, from each end of which hangs a rope *EG*, *BG*, and the lower end of this rope is wound about a roller *GG*. At one end, *H*, of this roller, is also fixed and wound around it another rope, the end of which depends from thence to the weight *I*, to which it is fastened. At the other end of the roller is a large wheel *KK*, around which also a rope winds, and then falls to the men *L* on the ground. The men by this rope pulling the wheel round, cause the roller to roll itself upon the ropes *GB* and *GE*, and thus as it revolves it ascends: at the same time the rope *HI*, with the weight at the end of it, is winding around the end *H* of the roller, and drawing up the weight; which therefore ascends, by the double motion, with double the velocity of the roller. This double motion must be considered, and allowed for in the length of the cords; or else the roller may be made of a less diameter at the part *H*, so as to retard the ascent of the weight. Also, as the two ropes *H* and *G* are continually approaching each other in the rotation, that approach must be allowed for in the length of the roller.

To obviate the objection, that in this machine part of the power is employed in raising the wheel and roller as well as the weight—at the end of the roller, next the wheel, is a ring *N*, from which a rope rises to the end *F* of the transverse piece *FE*, where, passing over a pulley, it is fastened to a mass of lead *M*, equal in weight to the wheel and roller; which by this means are counterpoized, and their weight prevented from acting against the moving power. But it must be observed that friction is thereby occasioned both in the pulley *E* and ring *N*, so that the machine is not entirely without friction.

(1*) The word *triental*, which signifies the third part of any measure, probably alludes to the measure of a foot; but it is doubtful whether we are to understand by it a piece of timber that is a third of a foot broad and a third of a foot thick (which is properly the ninth part of a piece that is a foot square), or a piece of timber that is an entire foot broad, and a third of a foot thick (which is truly a third part of a piece that is a foot square). All the translators of Vitruvius have understood it in the former sense: and yet it is almost impossible to be so; for timbers of that small scantling could not bear their own weight, at the length as they must have been; the length of the columns, according to Pliny, book 36, ch. 11, and consequently the length of these timbers, being sixty feet: they must in such a length bend to the ground, if not break in the middle. Secondly, the pivot and gudgeon together (called here *chodaces* and *armillæ*) would require to be at least the third of a foot in diameter, to have sufficient

fecured with lead, and fixed *armillæ*[2*] in the timbers to furround the chodaces ; alfo at the ends he bound poles (*F*) of oak. The chodaces were fo inclofed in the armillæ as to have room to revolve freely; fo that when the oxen were put under, and made to draw, the fhafts, by the chodaces turning in the armillæ, might revolve without ceafing.

Fig. LXXX. All the fhafts being thus carried, and the *epiftyliums* being alfo to be conveyed, Metagenes, the fon of Ctefiphon, applied this method of conveying the fhafts to the tranfporting of the epiftyliums[3*]: He made wheels (*A B*) of about twelve feet, and inferted the end (*C*) of the epiftyliums in the middle of the wheels, with chodaces and armillæ, in the fame manner; fo that, when the triental timbers were drawn by the oxen, the chodaces, being included in the armillæ, turned the wheels; and the epiftyliums being, as the fhafts were, like the axle of the wheels, they were without difficulty brought to the work. Examples of this are the cylinders with which they fmoothen the walks in the paleftras. But this could not have been done if the diftance had not been fmall; for from the quarries to the Temple it is not more than eight thoufand paces[4*]; nor is there any afcent, but it is a continued plain field.

In our memory, when the bafe of a coloffal ftatue of Apollo in the Temple was broken by age, left the ftatue fhould fall, and be alfo broken, they contracted for a bafe to be cut from the fame quarry. One Paconius undertook it. This bafe was twelve feet long, eight feet

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ftrength for the purpofe: confequently they would occupy the whole breadth of the timber; or, allowing them to be a little fmaller, they would occupy fo much of the timber as to leave the remainder of it too weak for its ufe. Thefe confiderations, therefore, oblige me to underftand the word *triental* to fignify a piece of timber that is a whole foot broad, and the third of a foot thick, which would then be no ftronger than the fervice required.

This obfervation may contribute to afcertain the true meaning of this and fimilar kind of words in other cafes.

(2*) The *chodaces* feem to be pivots or pins fixed in the center of the ends of the fhaft, as axles; and the *armillæ* to be the gudgeons or goujons let in the timbers to receive the chodaces: the latter, it may concluded, were of a dovetail fhape only in the part that entered the ftone, the outer part being neceffarily rounded that they might turn eafily in the gudgeons.

(3*) Galiani has here tranflated the word *epiftylium* by *cornici*; and in his notes reproves Barbaro and Perrault for tranflating it *architrave*: becaufe, he fays, it is probable not only the architrave, but the frize and cornice alfo, were thus tranfported. But here, if Galiani means that the whole entablature, i. e. architrave, frize, and cornice, were carried together, he muft be miftaken; for, as the columns were 60 feet high, if the entablature was any thing near the ufual proportion, the wheels could not contain it: and, if he means that they were carried feparately, then the architrave may as well be mentioned as the cornice; and the word *epiftylium* may fignify the *architrave*, as it generally does. Indeed it moft likely has that fignification in this place; for the wheels could not contain the cornice alone, fuppofing it to be of the ufual proportion, and in one piece. Galiani therefore muft be miftaken in this reproof.

(4*) *Millia paffuum octo—eight thoufand paces*—are the words written in all the manufcripts and printed editions: but in Chandler's Afian Travels, page 137, this paffage is corrected to *millia pedum octo—eight thoufand feet*; which he found to be about the diftance from the quarry on mount Prion to the fite of the Temple.

broad, and six feet high; which Paconius, with confident boldness, would not convey as Metagenes had done, but upon the same principle constructed another kind of machine. He made wheels (*A B*) of about fifteen feet, and in these wheels inclosed the ends (*C*) of the stone. Then from wheel to wheel, in their circumferences around the stone, he fixed two inch spindles (*D*), so as not to be more than one foot asunder: about the spindles he wound a rope (*E*); and the rope being joined to oxen that drew it, as it unrolled it caused the wheels to revolve: but he was not able to draw this in a right line; it always wandering to one side or the other, so as to require being drawn back again. Paconius therefore, by drawing and redrawing, consumed so much money, that he could not defray the expence.[5*]

Fig. LXXXI.

(5*) Some advantage, however, this machine of Paconius had over that of Ctesiphon and Metagenes; it had no friction, being like a roller: and if two drawing ropes had been wound around the two ends, instead of one only in the middle, they would, as Perrault well observes, have caused it to move in the line of draught; otherwise, small inequalities in the wheels, the irregularity of the road, or the drawing rope varying from the middle, would cause the machine to move out of the intended direction.

Another advantage of this machine is, that the moving power being applied at the circumference instead of at the center of the wheel, it had on that account double the power to overcome the obstructions and impediments of the road, and might therefore be moved with more facility: but it had this disadvantage attending it, that it was necessary frequently to stop and back the cattle in order to rewind the rope around it.—I differ from the other translators in my idea of the machine. They have placed the wheels as far apart as the stone, which was 12 feet long, would admit: but as the spindles were no more than the sixth part of a foot (sextantales), they would have been too weak with that extent to have sustained the pressure of the drawing rope, or even their own weight. For this reason I suppose the wheels were placed nearer together; probably so near, that one quarter of the length of the stone projected beyond the wheel at each end, as I have shewn it by *Fig. LXXXI.* Thus each half of the stone was exactly poised on each wheel; and it was thus less liable to be broken by the accidents and concussions it might meet with on the road.

But, even at this distance of less than six feet, spindles of two inches appear to be too weak for the purpose (unless they were of iron, which we have no authority for supposing). Planks of that thickness were more suitable, and I have some suspicion that planks should be understood; especially as the word *sextantales* is used, which, from the arguments in a note preceeding, seems more expressive of pieces of a foot broad, and two inches thick, than spindles of two inches diameter. Such planks would not be stronger than sufficient to bear the pressure of the rope by which the cattle drew the machine.

I

CHAPTER VII.

Of the Difcovery of the Quarry that produced the Stones for erecting the Temple of Diana at Ephefus.

I SHALL make a little digreffion to relate how this quarry was difcovered. A fhepherd named Pixodorus frequently wandered about the place: and at the time when the citizens of Ephefus were confidering of building the Temple of Diana with marble, and were debating whether to have that of Paros, Proconnefus, Heraclea, or Thafos, Pixodorus drove his flock there to feed. It happened that two rams encountering miffed each other; and one ftruck his horn with violence againft a ftone, a fhiver of which flying off, appeared to be exceedingly white. Pixodorus, it is faid, then left his fheep in the mountains, and ran fpeedily with the fhiver to Ephefus, where he related the circumftance. Upon this, honours were immediately decreed him; his name was changed from Pixodorus to Evangelus: and even at this day the magiftrate goes every month to the place, and facrifices to him; being, if he omit it, liable to a penalty.

CHAPTER VIII.

Of the ftraight and circular Motions of Machines for raifing of Weights.

I HAVE briefly explained what I judged was neceffary concerning tractorial machines, the movements and powers of which depend on two principles, different and diffimilar from each other, but fo agreeing, that the operation is perfected by both; one is rectilinearity, which the Greeks call *euthian*; and the other is circularity, which they call *cycloten*. But, in truth, neither the rectilinear motion without the circular, nor the circular motion without the rectilinear, can be effectual for raifing of weights. This I fhall explain, that it may be more intelligible.

The axles being fixed in the pulleys as centers, and placed in the trochleas, around theſe pulleys the ſtraight ropes are circumvolved; and the levers being inſerted in the ſucula, it is the rotation that cauſes the weight to aſcend. Of this ſucula, the axes, in the chelonia ſerving as centers, are rectilinear; and the levers put in the holes of it, being at their ends moved circularly in the manner of a wheel, occaſion by turning the riſing of the weight.

In like manner alſo, when an iron lever is applied to a weight that a multitude of hands cannot move, if under it, to ſerve as a center, a fulcrum, which the Greeks call *hypomochlion*, be laid[1*], and the tongue of the lever be put under the weight, the ſtrength of one man, preſſing at the end thereof, will raiſe the weight. This happens becauſe the fore part of the lever, the ſhorteſt from the fulcrum, which is the center, is under the weight; and the longeſt part is from this center to its head, which being moved in a circular line, the preſſure of a few hands poiſes the great weight of the load. So likewiſe if the tongue of the iron lever be put under the load, and its head be not preſſed downward, but on the contrary be lifted upward, the tongue, ſupported by the ground, will have that as the load, and the angle of the ſame load for the fulcrum: thus by a contrary method, although not ſo eaſily as by the fulcrum, the load will be moved. But if the tongue of the lever, lying upon the fulcrum, be put too far under the load, and its head be nearer the center of preſſure (i. e. the fulcrum), the load cannot be raiſed; nor unleſs, as above written, the poiſing part of the lever be the fartheſt from the head, and not neareſt to the load.

This may be obſerved in the balances which are called *ſtateræ* (ſteelyards); for when the handle, ſerving for the center, is ſituated near the end from whence the ſcale hangs, and the equipoiſe is moved over the points on the other part of the ſhaft, which is the longeſt, or is even carried to the extremity, a ſmall weight becomes equal, and ſuffices to balance a very great one, by the counterpoiſe and poiſing part of the ſhaft being the fartheſt from the center; and thus the lighter weight of the counterpoiſe balancing the greater power of the load, gently, and without violence, forces it to riſe upward.

(1*) *Suppoſita uti centro cito porrecta preſſione.* Perrault remarks that *ſuppoſita* ſhould be read *impoſita*, ſignifying that the fulcrum, *porrecta preſſione*, ſhould be put *upon* inſtead of *under* the lever, in which he is certainly miſtaken: for as Vitruvius ſays the tongue of the lever is under the weight, the fulcrum muſt conſequently be under the lever; and this is ſufficiently evinced by the ſignification of the Greek word *hypomochlion* (under lever), as Galiani well obſerves. Vitruvius is here ſpeaking of that ſort of lever where the fulcrum is between the weight and the moving power at the head of the lever; and he preſently afterwards deſcribes the other ſort, where the weight is between the fulcrum and moving power.

Likewife a fhip of great burthen is, by the fteerfman preffing fkilfully the handle of the rudder, which the Greeks call *oiax*, turned with the ftrength of one hand, it being upon the fame principle of the center (or fulcrum); and this notwithftanding it be laden with the weight of immenfe quantities of merchandize and provifions. When the fails alfo are hung at the middle of the height of the maft, the fhip cannot move fwiftly; but when the *antennæ* (fail yards) are drawn to the uppermoft point, it then moves with greater celerity, becaufe the fails are not near the foot of the maft, which is the place of the center, but are far above, and receive the wind at a diftance therefrom: for, as a lever put under a weight, if preffed at the middle, is more difficult to be moved, but when preffed at the head eafily raifes the weight; fo it is with the fails—if hung at a moderate height, they have lefs power; but if placed at the maft head, at a diftance from the center, with the fame, not with greater wind, acting at the topmoft point, they force the veffel onward with more velocity. The oars alfo that are bound with thongs to the *fcalmi* (oar pins), when they are impelled and pulled back again by the rowers, if their blades at the extremity in the fea extend far from the center (of motion), they more violently force the veffel forward, its prow cutting through the liquid body of the water.[2*]

(2*) Perrault difputes with Vitruvius concerning this doctrine of the fails and oars: He afferts that, whether the maft of a veffel be longer or fhorter, or whether the fails be put higher or lower, it affects not the motion of the veffel; for as the whole of it moves together, and there is no fixed point to ferve as a fulcrum or center of motion, it cannot be comparable to a lever, nor can it act as fuch: that it is fimply pufhed forward by the wind; and the only advantage of the fails being higher, is, that the wind is there ftronger: but that there is alfo a difadvantage therein; for the head of the fhip is by that means caufed to plunge more in the water, and thereby its courfe will be more impeded.

Perrault denies alfo that the oars act as levers. To this latter fubject Galiani has very well anfwered: but to the doctrine of the fails he has not replied; he only fays he could anfwer it, as he has done that relative to the oars.

A fhip floating on the water may be compared to a fufpended balance; the body of the fhip anfwers to the beam or arms of the balance, and the maft to the perpendicular tongue or index fixed in the middle of the beam: now if any power be applied to the top of the index, fo as to affect it horizontally, it caufes it to incline forwards, and puts the beam out of its equilibrium; which to reftore, either the top of the index muft return again to its former place; or the bottom of it, with the beam, muft move forward, fo as to be perpendicular to the top: but if the top of the index be prevented from returning to its place by the continued preffure of the power, and the beam be fo fufpended that it can change its place (for inftance, if it were fufpended on friction wheels, or on a cork floating in water), then the beam and bottom of the index will move forward to reftore the equilibrium. Thus, in a fhip, the power of the wind caufes the maft (by means of the fails) to incline forward, by that means putting the body of the fhip out of its equilibrium; and as the wind, by continuing its impulfe, prevents the top of the maft from returning to its former place, the body of the fhip is obliged, by its own gravity, to flide forward on the water, in order to recover the equilibrium: fo that the wind continually impelling the maft to incline forward thereby deftroying the equilibrium, and the fhip continually fliding forward to recover that equilibrium, caufe the uninterrupted progreffion of the veffel.

If this be the cafe, then the longer the maft, or the higher the fails, the lefs power will be required to incline the maft, and put the fhip out of its equilibrium; and confequently the maft acts in this refpect as a lever, the place of the fail being the manche or handle; the center of gravity of the veffel being the fulcrum; and the refiftance of the veffel to be put out of its equilibrium being the load. The maft then in this cafe acts not as a lever in preffing the fhip forward, but in putting it out

When heavy loads are carried by phalanxes[3*] of fix or four men, they are poifed in the middle of the phalanx, fo that an equal portion of the weight of the undivided load may bear upon the fhoulders of each of the porters. Therefore the middle parts of the phalanxes, which fecure the ftraps of the porters, are lined with iron clamps, to prevent their fliding from one fide or the other: for, when they move out of the middle, they prefs too much upon the fhoulder of him to whom they are neareft; in the fame manner as when, in weighing with the fteelyard, the counterpoife is moved toward the end of the fhaft.

On the fame principle cattle, when their yokes are by the girths of their collars adjufted in the middle, draw the load equally; and if their ftrength be unequal, and the ftrongeft preffes the other, putting forward the collar makes one part of the yoke the longer, which helps the weaker beaft. It is the fame in the phalanxes as in the yokes, when the ftraps are not difpofed in the middle, but one fide, to which the ftrap is moved, becomes the

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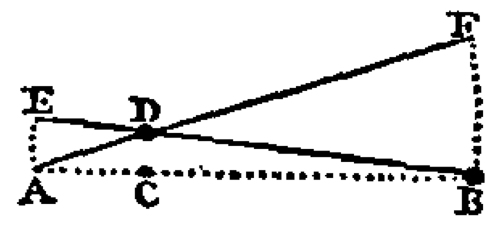
of its equilibrium, and thereby being the caufe of its progreffion forward; the immediate caufe of which is its own gravity, and effort to regain its equilibrium, joined to the momentum it acquires in that action. The fhip muft alfo undoubtedly receive a confiderable degree of velocity from the direct preffure of the wind upon its hull, as Perrault afferts; but in this way it receives as much aid by its body as by the fails.

With regard to the oars, Perrault maintains that "it is not upon the principle of a lever that the length of the oars contribute to the volocity of the veffel: for in a lever it is required that the longeft part from the fulcrum fhould be that next to the agent or mover; whereas in the oar it is directly the contrary, the longeft part being that toward the water."

There are two kinds of levers; one where the fulcrum is between the load and the agent, and the other where the load is between the fulcrum and the agent: the oar is of this latter kind; the veffel is the load to be moved, the water and the rowers are interchangeably the agent and the fulcrum. It is equal in effect whether the water pufhes the oar againft the rowers, or the rowers againft the water, provided one is ftrong enough to refift the other as a fulcrum. Now if a ftream of water run againft the end of an oar, the longer that oar is, the greater effect the water muft have upon it; and provided the rowers be ftrong enough to withftand the action as a fulcrum, then the oar muft prefs more forcibly upon the fide of the veffel, and thus caufe it to move quicker. It will be the fame in effect if the rowers pull the oar againft the water; for whether the rowers move their end of the oar



from *E* to *A* (the end *B* being held at reft by the refiftance of the water), or whether the water moves the other end of the oar from *F* to *B* (the rowers holding their end firm at *A*), the effect upon the veffel at *D* will be the fame; it will in both cafes be moved from *D* to *C*. It cannot be alleged that the oar never remains at one place in the water, but paffes through it; for that may or may not be the cafe, according as the veffel moves quicker or flower: it is alfo equal whether the water move againft the oar, or the oar againft the water.

From the above arguments it appears therefore that oars act on the principle of levers; and that the longer they are, the greater effect they muft have on the veffel, as Vitruvius afferts: but it always is fuppofed that the rowers muft be more numerous, or ftronger, in proportion as the oars are longer, to refift the greater power that the water has by that means on the oars.

There can however be no doubt that, the longer the part of the oar next the rower may be, the eafier it is for the rower to work it. But the fhape of fhips does not admit of fuch a conftruction; inftead therefore of giving greater length to that part of the oar, the power is fupplied by the greater number of the rowers.

(3[v]) The *phalanxes* here mentioned were machines for carrying burdens, fupported on the fhoulders of four or fix men; thence called *tetraphori* and *hexaphori.*

ſhorter, and the other the longer, from the center; for if, upon the point from whence both parts of the ſtrap proceed, the ends be circumacted, the longer part will deſcribe a larger, and the ſhorter part a ſmaller circle. Thus, as ſmaller wheels are harder and more difficult to move,[4*] ſo the phalangæ and yokes, in thoſe parts that have the ſmalleſt diſtance from the center to the ends, preſs hardeſt on the ſhoulders, and in thoſe that have a greater ſpace from the ſame center, both in drawing and carrying, diminiſh the preſſure of the load.

As theſe receive their motion by rectilinearity and circularity, relative to a center; ſo likewiſe the Plauſtræ, Rhedæ, Tympana, Rotæ, Cochleæ, Scorpions, Baliſtæ, Prela, and other machines, in the ſame manner actuated by the rectilinear and circular motions, perform their intended effects.

CHAPTER IX.

Of the ſeveral Kinds of Machines for raiſing Water, and firſt of the Tympanum.

I SHALL now diſcourſe of the machines[1*] that are invented for raiſing of water, of which various kinds are made; and firſt I ſhall ſpeak of the Tympanum: this does not raiſe the water high, but it diſcharges a great quantity in a little time.

(4*) Vitruvius here ſays that ſmaller wheels are more difficult to move than larger: but this muſt be underſtood conditionally, and not abſolutely; for if the plane on which they move, and their own ſurfaces, were perfectly ſmooth, then all wheels, large or ſmall, would move equally eaſy: or, if the axis and the obſtacles be in the ſame proportion to ſmall wheels as to larger, the effect will be the ſame when loaded with an equal weight; becauſe the levers by which they are moved are in proportion to the obſtructions and reſiſtances to their motion. Or, again, if we add to theſe conditions that there be no weight upon their axes, then large or ſmall wheels will be moved with equal facility, becauſe they in that caſe do not act as levers, but as rollers, puſhed or pulled onward by a force applied at their centers.

But as all wheels, as well as the planes on which they move, have numberleſs inequalities, and their axes are always preſſed with ſome weight, they muſt all have the obſtructions of the road and the friction of their axes to overcome; in doing which they act as levers, the radius or ſemidiameter of the wheel anſwering to the longer part of the lever from the fulcrum: ſo that ſmaller wheels, acting as ſhorter levers, muſt in general be more difficult to be moved.

(1*) Vitruvius's word is *organis*; but as that term would not ſuit the object in our language, it is rendered *machine*. See note 3, in the firſt chapter of this book.

Fig. LXXXII. An axis (*A*), either turned or worked round, is made, its ends being plated with iron, and having around it, in the middle, a *tympanum* (wheel) of boards (*B*)[2*] joined together; this is placed on posts (*C*), having also plates of iron under the ends of the axis. In the cavity of this tympanum eight planks (*D*) are inserted transversely, touching both the axis and the circumference, which divide the tympanum into so many equal spaces. Upon the front of it also planks are fixed, leaving apertures (*E*) of half a foot, to let in the water; and at the axis *columbaria*[3*] are sunk in the several spaces, so as to lead to one place. This, when pitched in the manner of ships, is turned by the walking of men[4*]; and receiving the water through the apertures (*E*), in the front of the tympanum, discharges it again through the columbaria at the axis: so that by placing thereunder a wooden trough (*F*), with a channel joined to it, the water is conducted to supply gardens, salt works, and various other uses.

Fig. LXXXII. When water is to be raised higher, the same contrivance may be altered thus: A wheel (*B*) is made round an axis (*A*), of such a magnitude as the height to which the water is to be raised, requires; around the extremity of the side of the wheel, square buckets (*G*), cemented with pitch and wax, are fixed; so that, when the wheel is turned by the walking men, the filled buckets being raised to the top, and turning again toward the bottom, discharge of themselves, what they have brought, into the reservoir.

Fig. LXXXIII. But, if a place of a still greater height be to be supplied, on the same axis (*A*) of a wheel (*B*) a double chain (*C*) of iron is wound, and let down to the level of the bottom, having brass buckets (*D*), each containing a congius (seven pints), hanging thereto; so that, upon the turning of the wheel, the chain revolving round the axis, raises the buckets to the top; which, when drawn upon the axis, become inverted, and pour into the reservoir (*E*) the water they have brought.

(2*) *Tympanum* here means *a hollow cylindric wheel*, so called from its being similar to a tympanum or drum.

(3*) At book iv. chap. 2. the grooves or channels in which the timbers lie, are called *columbaria*; which gives us to understand that by this word is meant some kind of channels or grooves.

(4*) Vitruvius does not inform us where the men that turned this wheel by their walking were disposed; they could not be within it, as in our warehouse crane wheels, because that part of this wheel is occupied by the water: Perrault therefore concludes that there must have been another wheel adjoined for that purpose, and represents it so in his engraving. But as Vitruvius describes no such additional wheel, which would be too important a part of the machine to be omitted in the description, I am disposed to believe that the operation was performed in some other manner: it might be done by men walking on the outside or convex surface of the wheel, having rails erected to secure them from accidents, as I have shewn in my drawing, *Fig. LXXXII.* And this may have been the antient, although not the modern, method of working these machines.

CHAPTER X.

Of Wheels and Tympanums for grinding of Corn.

THE ſame kind of wheels as thoſe before written are alſo made in rivers. Around their fronts are affixed pinnæ (*A*), which, when impelled by the current of the river, force the wheel to revolve; and the buckets thus drawing up the water, diſcharge it at the top, without the operation of walking; the impulſe of the river itſelf performing the whole work.

Fig. LXXXIV.

By the ſame means alſo the *hydraulæ* [1*] are turned; in which all the parts are the ſame, except that on one end of the axis they have a toothed tympanum (*B*) included [2*], which, by being ſet perpendicularly on the edge [3*], is turned equally with the wheel (*C*). Adjoining this tympanum a larger one [4*] (*D*), alſo toothed, is placed horizontally;

Fig. LXXXIV.

(1*) *Hydraulæ* is altered by Salmaſius to *hydromylæ*, *water mills*; the former word may however have been uſed by the Romans, as the common name of all machines moved by water.

(2*) *Tympanum dentatum & incluſum.*—Perrault objects to this phraſe, as expreſſing that the tympanum was included within the axis, inſtead of the latter being included in the former: but it is evident Vitruvius means as he has expreſſed it; for he uſes the ſame expreſſion again in this chapter, and I imagine it is to be underſtood to ſignify that the tympanum is included within the extent of the length, not within the body, of the axis. The ſame expreſſion is again repeated at the 14th chapter following, where it is evidently uſed in this ſenſe.

(3*) The words are, *in cultrum*, on the knife; a mode of expreſſion uſed to ſignify the being ſituated on the ſide or edge: and *a coltello* is at this day uſed by the Italians in the ſame ſenſe.

(4*) *Secundum id tympanum majus item, &c.*—*Majus* (larger) is changed to *minus* (ſmaller) by Perrault and Galiani; for, ſay they, "unleſs this laſt-mentioned tympanum was ſmaller than the former, the mill-ſtone which was adjoined to it would move ſlower than the water wheel, which may be too ſlow to anſwer the purpoſe, and is contrary to the preſent practice."

All the manuſcripts that I have examined, as well as the printed editions, agree in having *majus*, and not *minus*: and we ought to be cautious of altering the text in paſſages where all the copies agree; the rather as the antient mills may have differed from the modern ones in this reſpect, and yet have performed their office as well. For, although by ſuch a conſtruction the mill-ſtone would be moved ſlower, it would however be moved eaſier, as being moved by a longer lever; or, if the water wheel ſhould have been ſmaller than ours, it would revolve quicker, and thus cauſe the mill-ſtone to revolve as quickly as ours does. Or, thirdly, if the mill-ſtone itſelf ſhould have been larger, its velocity at the circumference may have been greater than that of a ſmaller mill-ſtone whoſe revolutions were quicker, and alſo would have contained a greater quantity of grain under action at the ſame time; ſo that the intention might be as well executed by a mill of ſuch a conſtruction, as by thoſe in preſent uſe. For theſe reaſons it appears unneceſſary to follow the example of Perrault and Galiani in deviating from the text.

Perrault has repreſented the mill-ſtone wheel as being compoſed of ſpindles, inſtead of teeth, as Vitruvius deſcribes; becauſe, he ſays, they are ſo at preſent: as if it were not poſſible for the antient mills to be made different from thoſe of the moderns.

in this is contained an axis (E), having at its upper end an iron dovetail (F), which is inſerted in the mill-ſtone (G): thus the teeth of the tympanum (B), that is included on the axis, impelling the teeth of the horizontal tympanum (D), cauſe the rotation of the mill-ſtone, to which the ſuſpended hopper (H) (infundibulum) furniſhes the grain; and by the ſame rotation the meal is ejected.

CHAPTER XI.

Of the Cochlea.

Fig. LXXXV. and Fig. LXXXVI.

THERE is a machine of the *cochlea* kind, that draws a great quantity of water, but does not raiſe it ſo high as the wheels; it is conſtructed thus: A beam (A) is provided, being as many digits in thickneſs as it has feet in length; and this is made round. At the ends (A) the circle (ACE) is divided with compaſſes either into four quarters, or eight octants, drawing lines; and theſe lines are to be ſo diſpoſed, that when the beam is erected level on a plain, both ends of the (reſpective) lines (AA, BB, CC, DD, EE) may correſpond in the perpendicular. After this, from one end to the other tranſverſe lines (F) are drawn, in ſuch a manner that, whatever the meaſure (AB) of the eighth part of the round of the beam may be, ſo large muſt be the ſpace (FF) between them, latitudinally. Thus both circumferently and longitudinally the ſpaces will be equal; and theſe lines, at the places where they are deſcribed, paſſing thoſe that are lengthways, make interſections, and thoſe interſections are marked by points. This being exactly deſcribed, a thin ruler, cut from willow or agnus caſtus, being anointed with liquid pitch, is fixed at the firſt point of interſection (A), from whence it is laid obliquely to the next interſection (2) of the longitudinal and circumferent lines; and ſo circumvolving, and paſſing through every point (3, 4, 5) in order, it is applied to every interſection, till it arrives and is fixed at that line which is on the eighth point (8) from the firſt, wherein the prior part of it was fixed: thus, as much as it paſſes obliquely through the ſpaces and eight points, ſo much it advances toward the eighth point in longitude. In the ſame manner, through all the ſpaces of longitude and circumference, fixing rulers obliquely at every interſection, and winding through the eight diviſions of the thickneſs, they form channels, and an exact imitation of the natural cochlea. On the other tracts, other rulers, alſo anointed with liquid pitch, are fixed, and added till the whole thickneſs becomes equal to the eighth part of the length. Then upon theſe the planks (G) are

fixed around, which cover the ſpirals ; the planks being ſaturated with pitch, and bound with iron hoops (*H*), that they may not be damaged by the action of the water. The ends of the beam are alſo armed with plates and nails of iron ; and in theſe iron pivots (*I*) are fixed.

On the right and left of the cochlea, beams (*K*) are diſpoſed, having tranſverſe pieces (*L*) adjoined at both ends, in which iron ſockets (*I*) are inſerted, that receive the pivots ; and then, by men walking (*M*), the cochlea is made to revolve. With regard to the erection of this machine, it muſt be diſpoſed in ſuch an inclination, that it may anſwer to that deſcribed in the right-angled triangle of Pythagoras, that is, the length being divided into five parts, the head of the cochlea (*I*) is elevated equal to three of thoſe parts ; ſo that, from the perpendicular thereof to the lower holes, will be the ſpace of four parts. *The manner in which this may be done, is ſhewn by the figure deſcribed at the end of the book.*

Thus, concerning machines for raiſing water that are made of timber, the manner in which they are conſtructed, and from what powers they receive their movement, affording numerous conveniences by their rotations, I have, in order that they may be known, written as clearly as I have been able.[1*]

(1*) This is that famous machine univerſally known by the name of the Screw of Archimedes : it is not always made with eight or four channels, as Vitruvius deſcribes it; but varies in that reſpect, having three, two, and ſometimes but one channel : nor is the inclination of thoſe channels, with regard to the beam or cylinder, always the ſame. Vitruvius has deſcribed them to be in an angle of 45, but they may be in an angle either more or leſs than 45 ; and the nearer they approach to a right angle with the cylinder, the more the head of the cylinder may be elevated, and the higher the water will of courſe be raiſed. It is this inclination, and not the number of the channels, as Perrault aſſerts, on which depends the height the water may be raiſed to, with a machine of a given length ; for all that is required to anſwer that purpoſe, is, that the channels ſhould have ſome declination from the level or plane of the horizon, that the water they receive may, as the cochlea turns, continually deſcend in its courſe. But, where there are many channels, they muſt be made narrower than where there are few, in order to preſerve the ſame inclination ; ſo that leſs water will be raiſed by each revolution of the machine.

Vitruvius informs us that this machine is alſo turned by the walking or treading of men ; but has not deſcribed the apparatus for this work, nor where or how it is performed. It cannot be well ſuppoſed that ſuch a wheel or tympanum, as is heretofore applied to the tractorial machines, could be annexed to this ; for, on account of the inclined ſituation of the cylinder or cochlea, the men could not ſtand upright therein : wherefore I muſt ſuppoſe (as at the ninth chapter foregoing) that ſuch operation was done by the men walking on the convex part of a wheel affixed to the end of the cylinder, as ſhewn by *Fig. LXXXVI.*

CHAPTER XII.

Of the Machine of Ctefibius.

Fig. LXXXVII. IT remains now to defcribe the machine of Ctefibius, which raifes water very high. This is made of brafs: at the bottom a pair of buckets (*A*) are placed, at a little diftance, having pipes (*B*) like the fhape of a fork annexed, meeting in a bafin (*C*) in the middle. At the upper holes of the pipes, within the bafin, are made valves, hinged with a very exact joint; which, ftopping the holes, prevent the efflux of the water that will be preffed into the bafin by the air. Upon the bafin a cover (*D*), like an inverted funnel, is fitted, which is adjoined and faftened to the bafin by a collar, rivetted through, that the preffure of the water may not force it off; and on the top of it a pipe (*E*), called the tuba, is affixed perpendicularly. The buckets (*A*) have valves placed below the lower mouths of the pipes, and fixed over holes that are in their bottoms; then piftons (*F*), turned very fmooth, and anointed with oil, being inclofed in the buckets, are worked with bars and levers from above: the repeated motion of thefe, up and down, preffing the air that is therein contained with the water, the holes being fhut by the valves, forces and extrudes the water through the mouths of the pipes (*B*) into the bafin (*C*); from whence rifing to the cover (*D*), the air preffes it upwards through the pipe (*E*); and thus from the low fituation of the refervoir raifes it to fupply the public fountains.

Nor is this the only one that has been invented by Ctefibius: there are many others, and of various kinds, which, by the means of fluids compreffed by the force of the air, reprefent fome natural actions; fuch as the Merulæ, that, when put in motion, utter voices; and the Engibatæ,[1*] that move images, feeming to drink; and other acts, entertaining to the fenfes of

(1*) The hydraulic devices, called Merulæ and Engibatæ, are now unknown. The former is, from the name, conjectured to be an imitation of the fhape and voice of a blackbird. The latter is by Barbaro fuppofed to come from the Greek word *engion, near:* but Baldus thinks it fhould be written *angibata*, coming from the Greek word *angeion, a vafe*; which explication Perrault has adopted, tranflating the paffage thus—" the little figures that are " made to move in glafs vafes, by means of the water " which the vafes have received."

Perrault here applies the word *libentia* to *engibata*, not to *figilla*; fuppofing, as he fays, it is not meant that the images drink, but that it is the *engibatæ* or *vafes* that receive the water. I however cannot be of his opinion, but agree in my tranflation with Galiani.

feeing and hearing. From among thefe, thofe that I have judged moft ufeful and convenient I have felected and treated of in the foregoing book of dialling, and in this of the raifing of water. The others, which are not for utility but for pleafure, thofe who are defirous of knowing, may find in the Commentaries of Ctefibius.

C H A P T E R XIII.

Of the Hydraulic Organs.

Fig. LXXXVIII. I MUST not omit to difcourfe briefly, and as explicitly as I am able, on the conftruction of the hydraulic organs.[1*] Upon a compact bafe *(A)* of timber an arca (ciftern) *(B)*, made of brafs, is difpofed; and to the right and left, upon the bafe, timbers *(C)* united in the manner of ladders are erected; between thefe are included brafs buckets *(D)*, with moveable piftons *(E)*, very exactly turned, and having bent and jointed irons *(F)* fixed to their middle, with levers *(G)* adjoined, and being covered with unfhorn fheep fkins: in the upper furface (of the buckets) are holes *(P)* of about three digits; near to which holes are brafs dolphins *(H)* fixed on turning joints, and having cymbals *(I)* hanging by chains from their mouths below the holes of the buckets.

Within the arca which contains the water is a kind of inverted funnel *(K)*,[2*] under which wedges *(L)*, of about three digits high, are laid, to level the fpace between the under lip of the pnigeus *(K)* and the bottom of the arca. Upon the neck of this (pnigeus) is fixed the little ciftern *(M)* which fupports the head of the machine, called by the Greeks *canon muficos.*

(1*) This defcription of the hydraulic organs has been thought to be unintelligible: fome of the tranflators have fhewn their ideas of their conftruction; but they are very far from being juft, as will appear by comparing the figure given by Barbaro and Perrault with the fketch here reprefented. I have obtained fome elucidation of the fubject from the works of fundry antient authors; particularly from Heron's Treatife of Pneumatics, which has enabled me to underftand Vitruvius fo far as to give a flight reprefentation of the general conftruction of thefe antient mufical machines. I have been obliged in many cafes to retain the original names of the members, there being no terms in our language fuitable.

(2*) This paffage—*ineft in id genus uti infundibulum inverfum*—is corrected by Turnebus to—*ineft pnigeus uti infundibulum inverfum*; and alfo *phigeos*, a little below, he changes to *pnigeos*. Thefe corrections appear to be juft; for Heron fays the inverted funnel, or hemifphere (as he calls it), was named *pnigeos*.

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In the length of this (canon) are channels (*N*), in number four if tetrachordic, fix if hexachordic, and eight if octachordic. In the feveral channels are epiftomia (ftoppers) (*P*), having iron handles (*Q*); which handles, when turned, open orifices (*O*) from the arca (arcula)[3*] into the channels. The canon has alfo holes (*R*) ranged tranfverfely, communicating with the channels, and correfponding to orifices (*S*) in the upper table, which in Greek is called *pinax*. Between the table and canon are difpofed rulers (*T*), which being perforated in the fame manner, and anointed with oil that they may be eafily moved to and fro, ftop thefe holes, and are called *pleuritides*[4*]; the paffing and repaffing of which alternately ftops and opens the holes.

Thefe rulers have iron *choragia*[5*] (*U*) affixed to them, and are united to pinnæ (*WVX*), the touching of which pinnæ caufes the motion of the rulers. Upon the table are the holes (*S*), through which the air from the channels paffes. To the rulers are fixed rings, in which the tongues of all the organic pipes (*Y*) are inclofed. From the buckets (*D*) proceed tubes (*Z*), united to the neck of the pnigeus,[6*] and communicating with the orifices that are in the arcula; in thefe tubes are fixed well-turned valves (*a*), which, when the arcula has received the air, ftop their apertures, and prevent its return.

Thus, when the handles of the levers (*G*) are raifed, the piftons of the buckets are drawn to the bottom; and the dolphins that are fixed on axes lowering the cymbals that hang from

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(3*) I am of opinion that *arcula* fhould be here read inftead of *arca*; for it is with the former that the channels immediately communicate, as has been juft expreffed.

(4*) This word is written *plinthides* in all the manufcripts that I have feen; although all the printed editions have *pleuritides*, as here written.

(5*) Vitruvius explains not what he means by *choragia*, which in Greek fignifies *dancers*. The commentators fuppofe fome kind of fprings are intended by that word: and this fuppofition feems to be well founded; for, by the defcription of Heron, it appears that a curved flat piece of horn *U* (Vitruvius fays, iron) was fixed before each ruler, and a ftring (of gut) *V* tied from the end of this horn fpring to the rulers *T*; which latter, when driven backward by the preffure of the hand on the pinnæ *X*, was by this means drawn forward again as foon as that preffure was removed.

Heron alfo gives us the defcription of the pinnæ, which Vitruvius has omitted. They were in the form of a right angle *VWX*; the perpendicular leg *VW* was joined at its lower end *V* to the ruler, with a moveable joint, and it alfo turned on an axis at its angle *W*: when therefore the end *X* was preffed down, it caufed the ruler to move backward; fo that the holes *TT* in the ruler, coincided with the holes *R* and *S* in the canon and upper table, and by that means admitted the air from the channels to pafs into the pipes *YY*, thus caufing them to found. But when the preffure at the end *X* was removed, the horn fpring *U* drew the ruler back again to its former place; and thus, the holes *T* in the ruler, no longer coinciding with thofe of *R* and *S*, the mouths of the pipes were thereby ftopped; fo that by preffing down the pinnæ (or keys, as we call them), in the fame manner as in our modern organs, the pipes were caufed to found.

(6*) Turnebus here alfo alters *ligneis cervicibus*, collars of wood, to *pnigei cervicis*, the collar of the pnigeus; and *lignea*, a little farther on, to *pnigea*. The correction is generally received by the tranflators; and appears to be right, for the reafons before mentioned.

their mouths, the cavities of the buckets become filled (with air). Then the pistons being raised into the buckets again, with frequent and strong pulsations, and thereby causing the cymbals to stop the upper holes, the air, which is there confined, is by the pressure forced into the tubes (*Z*), from whence it passes into the pnigeus, and through its neck into the arca[7*] (arcula); and the frequent motion of the levers still violently compressing the air, it rushes through the apertures (*O*) of the epistomia, and fills the channels with wind: when therefore the pinnæ are touched by the hand, they thrust forward and draw back the rulers, alternately stopping and opening the holes; and thus, by the art of music, sounds in an infinite variety of modulations may be produced.

I have thus endeavoured to explain, as well as I could by writing, this complex machine; but the construction thereof cannot be easily understood, except by those who are practised in things of this sort: those, however, who understand a little from the description, will, when they see the machine itself, more easily comprehend it, and will find the whole curiously and ingeniously contrived.

CHAPTER XIV.

Of the Manner of Measuring the Way when travelling.

WE now transfer our attention to a contrivance left us by the antients, that is very ingenious, and not unuseful; by which, while sitting in a chariot on the road, or sailing on the sea, we may know how many miles we pass; it is done thus:

Fig. LXXXIX. and Fig. XC. The wheels (*A*) of the chariot are to be in diameter four feet and a sixth;[1*] so that, a point being marked on the wheel itself, from whence it may begin its

(7*) *Arculam* should be here read instead of *arcam*, for the reason mentioned at note 3.

(1*) *Pedum quaternum & sextantis*, four feet and a sixth. Perrault and Galiani have altered this passage to *pedum quaternum*, four feet, for the following reasons: Vitruvius hereafter says, that in four hundred revolutions this wheel passes over a space of five thousand feet, or a Roman mile: the circumference therefore of the wheel must be twelve feet and a half; and, if so, the diameter can be but four feet, or thereabout; which is a fact. They also alter *pedum XII.* twelve feet, a little below, as

revolution on the ground of the road, when it arrives again at that point from whence it began to revolve, it will have paffed the exact fpace of XII. S. feet. This being prepared, then on the nave of the wheel, at the inner fide, a tympanum (*B*) is fecurely faftened, having one little tooth (*B*) projecting beyond the line of its circumference. At the feat of the chariot above, a little box is firmly fixed, having inclofed a moveable tympanum (*C*), difpofed perpendicularly, and fet on an axis. On the edge of this tympanum are made teeth, equally arranged, being in number four hundred, and fitting the tooth of the lower tympanum (*B*): alfo on the flank of the upper tympanum (*C*) is fixed a tooth (*C*), projecting farther than the other teeth. Then above this is a third tympanum (*D*), difpofed horizontally, toothed in the fame manner, and inclofed in another box: the teeth of this (latter) correfpond to that tooth which is fixed on the flank of the fecond tympanum (*C*). In this tympanum (*D*) are made holes (*e*), fo many as are equal to the number of miles the chariot may go in one day; whether more or lefs is of no importance. In all thefe holes round ftones are laid; and, in the theca or box of this tympanum, one hole has a little channel (*F*), through which the ftones that are put in the tympanum, when they arrive at that place, may fall into the feat of the chariot, and into a brafs vafe (*G*) there difpofed. Now, as the wheel revolves, it turns with it the lower tympanum (*B*); whofe tooth, in each revolution, impelling the teeth of the upper tympanum (*C*), caufes them to move round; fo that, when the lower tympanum (*B*) has revolved four hundred times, the upper one (*C*) will have turned but once, and the tooth that is fixed on its flank will have moved but one tooth of the horizontal tympanum (*D*): when therefore the lower tympanum has completed four hundred revolutions, and the upper has turned once, the diftance travelled will be five thoufand feet, that is, a thoufand paces (one mile). Now the ftones, by caufing a fou ndwhen they fall, give notice of every mile that is paffed; and the whole number of ftones being collected from the bottom, fhews the number of miles travelled in the day.

Fig. XC. In failing, likewife, a few parts being altered, the fame contrivance will anfwer. For an axis (*H*) being put through the fides of the veffels, with the ends projecting

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it is written in the printed editions of the text, to *pedum XII. S.* twelve feet and a half, for the fame reafons. Upon examining feveral manufcripts, I find they all agree with the printed editions, in having at the former paffage *pedum quaternum & fextantis*; but all differ from the printed copies at the latter paffage, in having *pedum XII. S.* not *pedum XII.* I conjecture therefore that the former paffage, although not really right, is perhaps right according to Vitruvius's intention, who might probably reckon the circumference of the circle to be but three times the diameter, as in a curfory manner it may have been fometimes computed (as it now is by our workmen), although not the accurate proportion of thofe parts of the circle. This conjecture is the more probable, as the fame words, *pedum quaternum & fextantis*, are again repeated further on in this chapter; which is a confirmation of its being the idea of Vitruvius, although not ftrictly juft: his own ideas, however, although erroneous, ought to be given by his tranflators; at the fame time that they may be accompanied with a notice of the error.

outward, on theſe (ends) are fixed wheels *(I)* four feet and a ſixth in diameter, having pinnæ *(K)* affixed round their edges, and touching the water. The middle of the axis, in the middle of the veſſel, has alſo a tympanum with one tooth *(B)* ſtanding beyond its circumference : at this place is a box incloſing another tympanum *(C)*, with four hundred teeth divided thereon, agreeing with the tooth of the tympanum *(B)* that is fixed on the axis *(H)*; it has alſo on the ſide another tooth *(C)* affixed, projecting from its circle. Above, in another box, is incloſed a horizontal tympanum *(D)*, toothed in the ſame manner[2*]; by which means the tooth *(C)* that is on the ſide of the tympanum *(C)*, that is placed edgeways, entering in the teeth of the horizontal tympanum, and in ſeveral revolutions moving the ſeveral teeth of the circle, cauſes the horizontal tympanum to revolve. In this horizontal tympanum are holes *(e)*, in which holes the round ſtones are laid ; and in the theca or box of this tympanum one hole is bored, having a channel *(F)*, through which the ſtone, when freed from the obſtruction, falls into a braſs veſſel *(G)*, and cauſes a ſound.

Thus, when the ſhip is propelled forward, either by oars or the wind, the pinnæ that are on the wheels touching the oppoſing ſtream of the water, that has a retrograde impulſe, turn the wheels ; theſe turn the axis to which they are joined ; and the axis turns the tympanum *(B)*, whoſe tooth, in the ſeveral revolutions, impelling the ſeveral teeth of the ſecond tympanum *(C)*, cauſes its regular rotations : ſo that the wheels, when they have been turned by means of the pinnæ four hundred times, move the horizontal tympanum once,[3*] by the im-

(2*) Theſe words, *toothed in the ſame manner*, are not, I believe, to be underſtood to ſignify that this horizontal tympanum is to have an equal number of teeth, but only that the teeth are to be formed ſimilarly; the number of teeth being at pleaſure, as in the horizontal tympanum of the chariot before deſcribed : for ſuch a number ſeems unneceſſary in the horizontal tympanum, being many more than the number of miles the veſſel can go in a day; and would, beſides, require it to be inconveniently large.

(3*) " Ita, cum quatercenties ab pinnis rotæ fuerint " verſatæ, ſemel tympanum planum circumagent im- " pulſu dentis qui adlatus eſt fixus tympani in cultro."— Perrault remarks that there is a miſtake in this paſſage; and ſo there would be, if the word *circumagent* ſignified the turning an entire revolution, as he has underſtood it ; for it muſt be the perpendicular tympan (having 400 teeth) that turns an entire revolution, while the water wheels (or thoſe with the pinnæ) revolve four hundred times ; and that perpendicular tympan having but one tooth in its circumference that touches the teeth of the horizontal tympan, this latter can turn only ſo far round as that ſingle tooth (of the perpendicular tympan) can turn it, while the water wheels revolve four hundred times.

Perrault would alter the reading to *tympanum in cultro*, the perpendicular tympanum—inſtead of *tympanum planum*, the horizontal tympanum. But if the word *circumagent* may be allowed to ſignify the turning a portion of a revolution only (as Galiani, as well as myſelf, thinks it may) then the text, as it ſtands, is perfectly right : and this indeed muſt be the meaning of the word in Vitruvius's idea ; for he ſays it is *turned once by the* (ſingle) TOOTH *of the perpendicular tympanum*. But he muſt have known that it is impoſſible for a wheel to be turned an entire revolution by a ſingle tooth of another wheel, howſoever conſtructed or connected with it, and therefore he could not intend to expreſs ſuch an idea : he muſt mean that it was moved ſo far round as that ſingle tooth could turn it, which muſt be equal to the diſtance of the holes wherein the ſtones were laid ; ſo that one ſtone might fall at each movement of the wheel.

pulſe of the tooth that is on the ſide of the perpendicular tympanum. Hence, as often as by the rotation of the horizontal tympanum the ſtones are brought to the hole, they are diſcharged through the channel; and thus by their ſound, and their number, indicate the number of miles navigated. I think I have now ſufficiently deſcribed the conſtruction of thoſe things that are prepared both for uſe and pleaſure in times of peace and ſecurity.

CHAPTER XV.

Of the Catapultæ and Scorpions.

I SHALL now treat of thoſe machines that have been invented for the purpoſe of defence, and preſervation from danger; namely, the Scorpions, Catapultæ, and Baliſtæ; with the rules and proportions by which they may be conſtructed: and firſt of the Catapultæ and Scorpions.[1*]

(1*) This part of the writings of Vitruvius has engaged the attention, and employed the abilities, of many able men, for ſeveral centuries paſt. The conſtruction of the antient military engines, of which this and ſome following chapters treat, has been long unknown; and the diſcovery of this curious part of antiquity has been conſidered as a reſearch worthy the endeavours of the learned and ingenious. When gunpowder, and thoſe immenſely powerful modern engines, cannons, became generally uſed, another mode of warfare neceſſarily commenced; the engines of the antients were gradually diſuſed, and were ſoon ſo entirely neglected that their formation was forgotten: and for ſeveral centuries paſt no example or remains, ſufficient to elucidate their conſtruction, have been known to exiſt; nor have the treatiſes written to explain them, by ſeveral antient authors, been hitherto underſtood. Valturius, Lipſius, Baldus, Buteus, and other modern authors, have publiſhed their reſearches on this ſubject; and almoſt all the tranſlators and commentators of Vitruvius have laboured thereon without ſucceſs. To obtain a knowledge of theſe engines, from the writings of Vitruvius alone, could not be expected; for his account of them cannot be called a deſcription. He mentions neither the form, uſe, or place of their ſeveral parts, but their names and proportions only; pre-ſuppoſing that their forms and parts were ſufficiently known, as they undoubtedly were in his time. But many of the names and terms that he uſes are now unintelligible, and the proportions are expreſſed in characters of whoſe ſignification we are doubtful: many of thoſe characters are corrupted and miſwritten by the copyiſts; differing in different manuſcripts, and diſagreeing with the account of other antient authors who have written on the ſame ſubject; ſo that there is no being certain on which we may or may not rely.

Daniel Barbaro, in his Italian tranſlation of Vitruvius, publiſhed ſo long ſince as the year 1556, commenting upon this part of Vitruvius's work, ſays, "It is here neceſſary that God aſſiſt us; for neither the writings of Vitruvius, nor any delineation, nor any antient remains of theſe engines, will afford us any aid." He adds, "I hope therefore I ſhall be excuſed for not attempting to explain things that by their difficulty, and almoſt impoſſibility, have defeated the attempts of men of much greater

Fig. XCV. All their proportions are determined by the length of the arrow that the machine is intended to difcharge; of which a ninth part is to be the magnitude of thofe

experience and ingenuity." Jocundus has given a figure of a balifta that he copied from Atheneus; but acknowledges that he neither underftands it, or the defcription of Vitruvius which he tranflates. Perrault alfo obferves that the account "given by Vitruvius of thefe engines has not been underftood by any perfon, although a great number have affiduoufly applied themfelves thereto: that the defcriptions given by Atheneus, Vegetius, Marcellinus, and other antient authors, are of no avail; neither will the reprefentations on the Trajan column, thofe in the book intitled Notitia Imperii, that which Du Choul copied from an antient marble, nor the model feen by Lipfius in the armory of Bruffels, afford any illuftration of the difcourfe of Vitruvius: and that it is no wonder that machines, difficult to be explained by writing, efpecially without delineations, fhould not be underftood from a defcription that was at firft neglected by the author;" and, he might have added, afterward corrupted and mutilated by thofe who have copied it.

Perrault however proceeds to comment upon divers parts of the difcourfe, and has attempted to give a reprefentation of a Catapulta. But it fo little accords with, and in fome parts is fo contradictory to, the words of Vitruvius, that it can only be confidered as a work of imagination: and his comments and conclufions may remain as inftances how far a difcourfe may be ftrained to fupport the moft foreign idea; and how far we may be mifled by our imaginations, when unguided and undirected by fome certain clue. This will more evidently appear to the reader upon comparing Perrault's comments with what is hereafter advanced.

Galiani, in his tranflation of Vitruvius, only recapitulates the difficulties attending the difcovery, and gives up the attempt: alleging that he does not believe the difcovery to be now among the poffibilities; and that he fhall therefore content himfelf with giving the tranflation according to the letter of the text, as others have before done.

Like the preceding tranflators, I have alfo endeavoured to difcover the formation of thefe antient machines, in order to make this part of Vitruvius's work more intelligible; but whether with better fuccefs, the public judgment will beft determine. I have diligently fought for, and attentively perufed, the authors who have written on the fubject, and believe I have obtained fuch a knowledge of it as will enable me to give the reader an idea of thefe curious antient engines; the defcription of which here precedes the difcourfe of Vitruvius, that his account, being afterward read, may be the better underftood.

The military engines of the antients were diftinguifhed into the *euthytonæ* and the *palintonæ*; the former were thofe that difcharged arrows, darts, &c. and the latter thofe that difcharged ftones, or both ftones and arrows: of the former kind were the Scorpion and the Catapulta; of the latter, was the Balifta. Thefe names were generally thus applied in the time of Vitruvius, although in after times they were often confounded one with the other.

The Scorpion was the fmalleft and leaft powerful; it was fo called from being in form a little like the infect of that name. It confifted of a bow *A A*, *Fig. XCI.* made either of fteel, or of fome elaftic wood, having a cord of finews ftrained from one end to the other, and faftened in holes made at the ends for that purpofe. To its middle was joined the regula *B B*, having in its upper furface a channel *C*, of a dovetail fhape, the lower part being the wideft. This regula was called the *fyrinx*; it was made of hard wood, and was fixed upon a board *D E*, a little longer and broader than itfelf, called the *catagogis*. Upon the fyrinx was difpofed another regula, *Fig. XCII.* equal in breadth, and nearly in length, to the fyrinx, and having a dovetail mafculus *F*, fitting the fhape and fize of the dovetail channel in the fyrinx. This latter regula was called the *dioftra*; and being placed in the fyrinx, with its mafculus inferted in the dovetail channel *C*, it might be flid to and fro thereon, without danger of feparating. In the upper furface of this dioftra was made a femicircular channel *G*, the whole length, called *epitoxis*, wherein the arrow was laid; and near the end thereof, fartheft from the bow, were two upright iron cheeks *HH*, *Fig. XCIII.* called *catochas*, and which were fixed upon the dioftra a little diftance afunder: between thefe was placed an iron grapple or hand *I*, called *chira* and *manucla*: one end of this was bent backward like a hook, and cloven fo as to admit the thicknefs of the arrow between; the other end was pointed. Through the fides of the catochas and chira was put an iron axis *K*, fo that the chira had a vertical rotation thereon. Under the pointed end of the chira lay the end of a thin iron bar *L M*, which was fixed to the upper furface of the dioftra, on the left hand of the epitoxis, by an iron pin, on which it turned horizontally. This bar was called the *fchafteria*: and while its end *L*

holes (*IL KM*) in the capitules, through which are diſtended the twiſted cords of ſinews that retain the arms of the catapultæ; and by theſe holes the height and breadth of the capitule is thus determined.

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remained under the end of the chira, it prevented the latter from turning on its axis; but when removed, by drawing forward its end *M*, admitted the hooked end *I* of the chira to turn over to the place of the pointed end *L*, which end conſequently turned under to the place of the hooked end, a chaſe being cut in the dioſtra to admit its paſſing. The ends of the bow were ſo curved upward, that the bow-ſtring might freely paſs over the upper ſurface of the dioſtra, although the middle part of the bow was lower than the maſculus at the under part of the dioſtra. The catagogis was rounded at the end *E* next the bow, and was hollowed at the other end *D*; in which hollow, *D*, the archer applied his belly. He then puſhed the dioſtra forward, till the chira *I*, *Fig. XCIV.* arrived at the bow-ſtring, which latter he put over the hooked end of the chira; the ſchaſteria being previouſly put under the pointed end of the chira, to prevent its turning round and letting go the bow-ſtring. He then with all his power puſhed the farther end *F* of the dioſtra againſt ſome wall, or againſt the ground, keeping his body in the hollow *D* of the catagogis, and by theſe means forced the dioſtra and chira toward him; and, the chira having hold of the bow-ſtring, this latter was alſo drawn toward him, and the bow thereby bent.

To prevent the dioſtra being drawn back again by the bow, the following contrivance was uſed: An indented ruler *N* was fixed to each ſide of the ſyrinx, along its whole length; and an iron catch *O*, called *cataclida*, turned on an axis vertically on each ſide of the dioſtra: as therefore the dioſtra moved onward, the cataclidæ fell ſucceſſively between the ſeveral teeth of the ruler, and thus prevented the dioſtra from being drawn back again by the bow.

When the bow was bent as much as was judged ſufficient, and held ſo by the cataclidæ, the archer laid the arrow in the epitoxis, inſerting the feathered end between the cloven parts of the chira quite home to the bow-ſtring, which entered a notch made in that end of the arrow for that purpoſe. He then raiſed the whole machine, took his aim by looking along the arrow; and then, taking hold of the outer end *M* of the ſchaſteria, drew it toward him, and of conſequence drew the other end of the ſchaſteria from under the chira; which by the pull of the bow-ſtring inſtantly turned on its axis, and thereby let free the bow-ſtring, and diſcharged the arrow with great force.

This machine, on account of its effect being produced by the application of the belly, was called *gaſtrapheten*.

The Catapulta was an engine for the ſame uſe, but of greater power. To increaſe the power in a great degree, without greatly increaſing the ſize, and thereby rendering the machine too unwieldy and unmanageable, required ſome difference in the conſtruction; and chiefly in the part that was the cauſe of its power, *viz.* the bow. But if the power of the bow or arms were increaſed, it became neceſſary alſo to increaſe the power that acted on thoſe arms. This, inſtead of being done by the additional ſtrength of men, was more conveniently and effectually done by the application of ſome mechanical power; and this occaſioned another difference in the machine. Theſe differences therefore were as follows: Inſtead of a bow, as in the ſcorpion, the catapulta had a rectangular frame of wood *ABCD*, *Fig. XCV.* conſiſting of four upright pieces placed at proper diſtances; and two horizontal pieces, one *AC* over, and the other *BD* under, the ſaid four upright pieces, and to which they were ſtrongly connected by tenons and iron plates. The horizontal pieces were called *ſcutulæ* and *tabulæ* by the Romans, and *peritretæ* by the Greeks. The two outer upright pieces, *AB* and *CD*, were called *paraſtæ*; and the two inner ones, *EF* and *GH*, *meſoſtæ*. The whole frame is called by Vitruvius the *capitule*, and by Heron the *plinth*. Holes *IKLM* were bored perpendicularly through both the peritretæ, in the middle between the paraſta and meſoſta, both on the right and left ſide of the capitule. Acroſs the holes of the upper peritreta were laid two ſtrong iron bars *IL*; and two more *KM* were applied to the holes, in the ſame manner, under the lower peritreta: theſe iron bars were called *epizyges*. Then to the upper epizygis *I* one end of a cord of gut or ſinews was tied; and the other end carried through the holes of both the peritretæ to the lower epizygis *K*, ſtrained round it, and carried again through the ſame holes to the upper epizygis *I*, around which it was ſtrained, and carried again in the ſame manner to the lower epizygis: and thus repeated till the holes were quite filled, and would admit no more of the cord to paſs. In the middle *N* of this complication of cords, one end *N* of an arm of ſteel or elaſtic wood was inſerted, the other end *O* projecting beyond the face of the adjacent

parastæ AB; and then the two epizyges IK were turned about, so as to twist the cords with great violence: by this means the arm NO was held fast, and caused to press backward with great force against the face of the parasta AB, where it entered a semicircular excavation R, made there to receive it. The same operation was repeated on the other side of the capitule with the epizygis L and M, and the arm PQ; and the two arms thus held by the twisted cords of sinews acquired a great degree of elastic power, and answered the purpose of the bow in the before-described scorpion.

Through holes made at the ends O and Q of the arms was put the bow-string OQ, which was a cord of sinews of the strongest texture; and was of such a length as to sustain the arms at a little distance from the parastæ, that in their recoiling they might not strike against those members, and be thereby damaged: or a cushion was sometimes placed there for that purpose. The arms were called *brachia* and *ancones*; the complication or column IK of twisted cords that held the arms was called *hemitonus*, and sometimes *unitonus*. The interval FH between the two hemitones was left for the syrinx and diostra, formed as in the scorpions; the end of the syrinx being firmly fixed upon the upper surface S of the lower scutula or peritreta.

Heron describes another capitule, with some but with no material difference: the scutula or peritreta being made in shape like a semi-octagon $ABCDEF$, *Fig. XCVI.* so that it was broader in the middle than at the ends; and the two mesostæ GE and HD were consequently broader than the two parastæ AF and BG; the breadth of each being determined by the intersection of the inner sides I and K of the parastæ, and the outer sides E and D of the mesostæ, with the semicircle $AIEDKB$, as shewn by the figure.

Fig. XCVII.

To the capitule AA, thus formed, was fixed, as before said, one end of the syrinx B, being, with the diostra CH, chira and schasteria D, and cataclida O, made in all respects the same as before described in the scorpion, but without the catagogis; instead of which a sucula or windlass E was connected to the other end of the syrinx, whose sides F projected forward in order to receive it. To the middle part G of this sucula, between the two sides of the syrinx, was fixed a cord GC, extending from thence to the end C of the diostra, where it was fastened to a hook; when therefore the machine was prepared as described in the scorpion (that is to say, the diostra pushed forward till the chira arrived at the bow-string IKI, and hooked it), the diostra was drawn back again by means of the sucula, which was turned round by two men, with the assistance of levers L put through each end of the same; and thus the arms I were drawn and strained: this being done sufficiently, the arrow KH was then laid in the epitoxis, and discharged in the manner before described.

The larger engines of this kind, in which the power was very great, were drawn by pulleys in various combinations, or with pulleys and suculæ connected together: and instead of the simple iron axons, or epizyges, that sustained the tonus of cords, the machines M, called by Vitruvius *modiols*, and by Heron *choenices*, were used; and which will be explained in the description of the Balistæ.

This engine being too large and heavy to be managed in the hand, and being required to be turned and elevated in different directions, it became necessary to support it on a base that should afford the required conveniences. This base was thus constructed:

A post N (or *columella*, as Vitruvius calls it), about two feet and a quarter high, was fixed upright upon a three-legged base PQR, and supported by three braces SSS on the same. At the top of the columella was a cylindric tenon T, on which turned the chalchesium U, a, V, which was formed thus:—On a horizontal rectangular board UV two perpendicular rectangular sides Ua, and Vb, were fixed to the right and left; and between these was another horizontal board bcd, a little above the former.

Through the middle of the two horizontal boards holes capable of receiving the tenon T of the columella were bored. The two perpendicular sides were so far apart as to admit between them the breadth of the syrinx; which being introduced, an iron axis e passed horizontally through the sides of the chalchesium and those of the syrinx, connecting them together, and admitting the syrinx to turn vertically on the said axis: so that the whole catapulta could be elevated and declined to any direction: and, by the chalchesium turning on the tenon of the columella, it could also be turned horizontally to any direction required, and by these means be pointed against any intended object.

To keep it steadily fixed when thus directed, one end f of a piece of timber fg was annexed to the top of the columella, by a joint that admitted it to turn horizontally; so that the other end g, resting on the ground, might be placed in different situations. This piece was called *anteridium*; near to the upper end of which the *anapausteria*, bi, was annexed, with a joint admitting it to be elevated and declined. When therefore the syrinx was set to its re-

parallels, are made one hole in thickneſs, in breadth one and three quarters,[2*] and at the extremities one hole and S.[3*] The paraſtæ (*AB* and *CD*) on the right and left, without the tenons (cardines), are made four holes high, and five holes thick; the tenons (*AB*) S. Q. of a hole. From the hole to the middle paraſta (*EF*) it is alſo S. Q. of a hole.

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quired direction, the lower end *g* of the anteridium was moved, and fixed to the ground, ſo that the anapauſteria might remain perpendicularly under the ſyrinx: and then the end *i* of the anapauſteria was raiſed, and fixed to the bottom of the ſyrinx, in holes there made; by which means the ſyrinx was kept firm in its poſition till the arrow was diſcharged.

The catapultæ were made of different magnitudes: but there were two ſizes moſt generally uſed, of which the ſmaller were called *triſpithamal*, becauſe they threw arrows of three ſpans long; and the larger were called *tricubital*, becauſe they threw arrows of three cubits, or ſix ſpans, long.

The proportions of their ſeveral parts are given by Vitruvius; but they are ſo corrupted as not to be truſted to. Heron ſays all the proportions muſt be determined by experience and trial. Philo mentions many of them, and therein differs greatly from Vitruvius. They all agree, however, that the proportions were regulated by the ſize of the holes in the ſcutula, and that the diameter of thoſe holes was always made equal to a ninth part of the length of the arrow that the catapulta was intended to diſcharge.

(2*) It is not always eaſy to diſcover the parts to which the terms of Vitruvius allude: thoſe that have appeared to me to be meant, I have referred to by letters. The term *tabula* here mentioned ſeems to me to allude to the horizontal pieces *AC* and *BD*, *Fig. XCV.* called *peritreta* by the Greeks.

Galiani has tranſlated this meaſure "one and one eighth," inſtead of one and three quarters; probably by miſtake.

(3*) It may be proper, before we proceed farther, to take ſome notice of the characters Vitruvius uſes in treating this ſubject, as they are differently underſtood by the different commentators. Their different opinions are ſhewn in the following table; and this mark * is added to thoſe which agree with my own.

CHARACTERS.	Their Significations according to				
	Philander.	Jocundus.	Meibonius.	Perrault.	Galiani.
S.	$\frac{1}{2}$ *	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$ *
Mark of a Sicilicus, or $\frac{1}{4}$ of an Ounce 9.	$\frac{1}{4}$ *	—	$\frac{1}{4}$	$\frac{1}{16}$	$\frac{1}{4}$
$\overline{\Gamma}$	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{3}{16}$ *	$\frac{1}{4}$	$\frac{1}{16}$
K	—	—	$\frac{1}{16}$ *	$\frac{1}{4}$	$\frac{1}{16}$
Z	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$ *	$\frac{1}{8}$	$\frac{1}{6}$
ξ or ʒ	—	—	$\frac{1}{12}$	$\frac{1}{12}$	$\frac{1}{12}$
: —	—	—	$\frac{1}{4}$ *	$\frac{1}{8}$	$\frac{1}{4}$
F	$\frac{1}{12}$	$\frac{1}{12}$	$\frac{6}{16}$ *	$\frac{1}{12}$	$\frac{1}{6}$
A Duella, or $\frac{1}{3}$ of an Ounce $\overline{U}$	$\frac{1}{3}$ *	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
• •	—	—	$\frac{1}{16}$ *	—	—
∴∴ ⁘	For periods in the Diſcourſe.				

The breadth of the middle paraſtæ (*EF* and *HG*) is one hole and ΓK, the thickneſs one hole; the interval where the arrow is placed between the middle paraſtæ is the fourth part of a hole. The four angles that are on the ſides and fronts are ſecured with iron plates, or braſs bars and nails.

The length of the canalicule (*CC, Fig. XCI.*), which in Greek is called *ſtrix*,[4*] is XIX. holes. The regulæ (*BB*), which ſome call *bucculæ*, that are fixed on the right and left of the channel, are XIX. holes; the height and thickneſs one hole: alſo two regulæ (*FF. Fig. XCVII.*) are affixed, in which is inſerted the ſucula (*EE*), being three holes in length, and half a hole in breadth. The thickneſs of the buccula that is affixed, called *camillum*, or, according to ſome, *loculamentum*, being fixed with a dovetail tenon, is I. hole, the height S. of a hole. The ſucula is in length[5*] :·: holes :::. The thickneſs of the ſcutula is IX. holes. The epitoxis (*GG*) is in length S :—· holes; in thickneſs :—. Alſo the chelo (cheira), or manucla (*I, Fig. XCII.*), as it is called, is in length III. holes, in breadth and thickneſs S :—· The length of the *fundus*[6*] of the channel is XVI. holes, the thickneſs a hole :·:, the breadth S :—·

The columella and baſe on the ground is VIII. holes; the breadth in the plinth in which the columella is fixed up, is S:—· The thickneſs F. Z. The length of the columella to the tenons is XII. holes :·:; the breadth S:—· of a hole. The thickneſs Ū.9; its three capreals (braces) are in length IX. holes, in breadth half of a hole :::, in thickneſs Z. The length of the cardo (tenon) a hole :·:. The length of the head of the columella I. S. K. the breadth of the *anteſixa* S. :·: 9. of a hole, the thickneſs I. The poſterior ſmaller column, which in Greek is called *antibaſis*, is VIII. holes; the breadth S. I. of a hole, the thickneſs F. Z. The *ſubjectio* is XII. holes, the breadth and thickneſs is the ſame as that of the ſmaller column. The *chelonium*, or *pulvinus*, as it is called, upon the ſmaller column, is II. S. :·:; the height II. S. :::;

(4*) Some commentators allege *ſyrinx* ſhould be here written inſtead of *ſtrix*; the former being the Greek name of a pipe. Heron uſes the term *ſyrinx*, as appears by the foregoing deſcription of the catapulta. But it may be obſerved that the thing here ſpoken of, is a channel, not a pipe; and that Vitruvius, ch. iii. b. iv. has applied the term *ſtrix* to the channel of a column. I have therefore left the word as in the text.

(5*) The number ſpecifying the length of the *ſucula* is wanting in all the copies. Galiani taking it from Ceſariani, has added *VIII. S. eight and a half*, for its length; and Barbaro, with Perrault, *nine*. But the length of the ſucula has juſt before been ſaid to be three holes; from whence I imagine that *ſcutula* has been here originally written, eſpecially as the thickneſs of that part immediately follows.

(6*) *Canalis fundi* is rendered by the tranſlators *the bottom of the channel*, and *the channel of the bottom*: but as, at the 13th chap. preceding, the term *fundus* is ſeveral times uſed for the *ſtoppers* or *ſliders* that move in the buckets or modiols, it appears to me probable that the word *fundus* is uſed as a technical term in this place, and ſignifies ſomething of the ſame kind. The epitoxis is the part *GG, Fig. XCII.*; and the *chelo* or *manucla* ſeems to be that called *cheira* or *hand* by the Greeks. At the 18th chapter following, the cheeks on each ſide the cheira are called *chelonia*.

the breadth S. I. :—. The charchebi[7*] of the fucula II. S. I. ∴:, the thicknefs S. II. ∴:, the breadth I. S. The length of the tranfverfe pieces with the tenons X. ∴:, the breadth I. S. ∴:, and the thicknefs ten. The length I. S. of the arms (brachia) (*O O*, *Fig. XCV.*) is VII. holes, the thicknefs at the root F. Z. of a hole, at the top Ū. Z. of a hole; the curvatures eight holes.

In thefe proportions, either enlarging or diminifhing occafionally, they are prepared; for, if the capitules (*A B F E*, *Fig. XCV.*) be made higher than the breadth, as are thofe called *anatona*, the arms are fhortened; that, where the tonus is weakened by the height of the capitule, the fhortnefs of the arms may aid the force of the ftroke. If the capitule be lefs high, which is called *catatonum*, the arms, on account of the great power, are made a little longer, that they may be more eafily drawn; for as, in the cafe of a lever, if when it be four feet in length a given weight may be raifed with it by five men,[8*] when eight feet long that weight may be raifed with it by two—for the fame reafon the arms that are longer are eafier, and thofe that are fhorter are more difficult to be drawn.

CHAPTER XVI.

Of the Baliftæ.

I HAVE fpoken of the rules by which the parts and proportions of the Catapultæ are determined; but the principles of the Baliftæ vary, and are different, although prepared to produce fimilar effects. For fome are worked with levers and windlaffes (fucula), fome with fheaves of pulleys (polyfpaftons), others with capftans (ergatæ), and fome alfo with wheels (tympanums). No balifta, however, is made without having regard to the weight of the ftone that the machine is to throw; their principles therefore are not eafy to all, but to thofe only who have a knowledge of arithmetical rules and the powers of numbers: for in

(7*) *Charchebi* is corrected by Philander and others to *carchefii*: this latter word is mentioned at the 5th chapter foregoing, and at the 22d chapter following, but is not at either place explained. It probably relates to that member which in the foregoing defcription is called *chalchefium*.

(8*) As two men with a lever of eight feet are equal in power to four men with a lever of four feet, here is moft probably a miftake; and inftead of *quinque*, five, it fhould have been written *quatuor*, four; to which Galiani has altered the text.

their capitules are made holes, through which cords of hair (that of women chiefly), or of ſinews, are drawn, and whoſe magnitudes are adjuſted by the laws of gravity to the weight of the ſtone that the baliſta is intended to diſcharge; as thoſe of the catapultæ are to the length of the dart. However, that thoſe who are unacquainted with arithmetic or geometry may be prepared, and not be occupied by ſtudy, in the time of the dangers of war, I ſhall here reveal what I have acquired by my own experience, as well as what I have learnt from authors; and as the rules of theſe things are founded on the weights and meaſures of the Greeks, I ſhall tranſcribe them ſo that they may alſo agree with our weights.[1*]

(1*) The capitule *AIHB*, *Fig. XCVIII.* of the baliſta was formed ſimilarly to that of the catapulta, excepting that the two hemitones *AFHC* and *DIEB* were diſpoſed farther apart, leaving a wider interval *CE* between the two *meſoſtæ GG*, which in the baliſta were called *antiſtæ*. The purpoſe of this engine, which was to throw large ſtones, required ſo large an interval: Heron ſays it ſhould be a little leſs than double the length of the arms *R S*.

The ſcutulæ or peritretæ *AF* and *DI*, which in the catapulta extended in one piece over both hemitones, were in the baliſta ſeparate, and extended over one hemitone only. The lower peritretæ *H C* and *E B* were alſo disjoined in the ſame manner; ſo that the two hemitones were not connected by their peritretæ, but by two other pieces of timber *K L* and *M N*; one of which *K L* extended over the two upper peritretæ, and the other *M N* under the two lower peritretæ; being ſecured to the ſame by tenons. The paraſtæ *O* were made like thoſe of the catapulta, but had a curvilinear protuberance *P* at the back part, oppoſite the circular cavity *Q* in which the arm lay, in order to ſtrengthen it. The antiſtæ *G* had alſo a curved protuberance toward *R*, called *hypopterna*, on the ſide toward the root of the arm, againſt which the ſaid root *R*, called *ptena*, reſted. The grain of the wood in the paraſtæ and antiſtæ was perpendicular; and tenons from the top and bottom of both entered the peritretæ, to ſecure them thereto. All the angles and joints of the whole capitule were fortified with iron plates.

The peritreta in this engine was made of a rhomboidal figure, in order to permit the arms to diverge the more. Heron deſcribes it thus:—In a rectangular parallelogram *a b c d*, *Fig. XCIX.* whoſe breadth is half its length, a diagonal line *a c* is drawn; parallel to which is drawn *b e*; *d a* is continued to *e*; then *a e b c* ſhews the figure of the peritreta: the ends *a e* and *b c* being ſwelled in a curve, to ſtrengthen it. Again, drawing *c e*, the interſection *f* of that line, with the line *a b*, ſhews the middle of the peritreta, where the hole of the tonus is bored.

Philo gives another rule for determining the obliquity or rhomboidal figure of the peritreta:—He ſays, divide a ſemicircle into eleven parts, and from the fourth diviſion draw a line to the center; which line ſhews the obliquity required. Vitruvius differs from both: he ſays the oblique formation ſhould be a ſixth part of the length, and a fourth of the breadth.

The capitule of the baliſta being finiſhed, the other members, anſwering to the ſyrinx, dioſtra, &c. of the catapulta, were added, as follows: To the timber *M N*, *Fig. XCVIII.* under the lower peritreta, was connected an horizontal frame of timber work *A B C*, *Fig. C.*; it conſiſted of ſeveral pieces of timber *D D D*, diſpoſed at equal diſtances the whole length of the capitule, projecting forwards, and being connected at their projecting ends by a tranſverſe timber *A B*. This frame was called *menſa*, and by the Greeks *trapeza*; upon it was laid the covering of boards *E E* called *tabula*, whoſe upper ſurface was level with the bottom of the lower peritreta. Upon the tabula was placed the *climax*, or, as Vitruvius calls it, *climaciclos*, *FGG*, which was a horizontal frame of timber, ſimilar to a ladder, whence it took its name; being compoſed of two longitudinal pieces *GG* and *FK*, connected by ſeveral tranſverſal pieces *HH*, at proper diſtances. The breadth of the climax (according to Heron) was equal to the interval between the antiſtæ; and the length nineteen holes according to Philo, although but thirteen according to Vitruvius. This climax anſwered to the ſyrinx of the catapulta, and lay upon the tabula, ſo as to project over each ſide of the ſame. Upon the two parallel longitudinal pieces of the climax were laid two others, called *alæ*, *I I* and *K K*, of equal length and breadth; between which, and over the tranſverſe pieces *H H* of the climax, was the dioſtra *L L L*, being equal in length to the climax. The climax was firmly faſtened on the menſa, and ſecured by the anterides or braces *M M*, extending from the ends of the alæ to the upper peritreta.

The Cheira, Schaſteria, &c. *O P* were fixed upon the

dioftra in the fame manner as in the catapulta: but here the hooked end *P* of the cheira was not forked or cloven, but made like a finger; and the cheira was raifed fo far above the dioftra, that the bow-ftring, when forced therefrom, might feize the ftone *Q* to be difcharged about the middle of its height, that it might act more powerfully and certainly thereon. With the fame intention, the arms *R R* were difpofed fo as to caufe the bow-ftring in its recoil to move at that height above the dioftra: alfo the bow-ftring *S S* was made broad like a belt, not round like that of the catapulta; and it had a loop *P* in the middle, which hooked over the finger of the cheira. Thefe engines were made of the ftrongeft and tougheft wood; and as light as a proper degree of ftrength would admit, that they might be the eafier conveyed from place to place; for which purpofe alfo all the parts of the large engines were made to take afunder, excepting the hemitones, which always remained entire, on account of the difficulty and time required to prepare the tonus *T T*; the method of doing which is defcribed at the eighteenth chapter following.

In the baliftæ and larger catapultæ, inftead of the fimple iron axons or epizyges before mentioned, the machines *Fig. CI.* and *CII.* were ufed. They are called *choenices* by Heron, and *modiols* by Vitruvius; and were made, when fmall, of brafs; when large, of fome hard wood. The part *a* was fquare, and lay upon the peritreta *c c*, over the hole of the tonus. The part *b*, above it, was circular; in the middle of the circle a hole *d d* was bored quite through the choenicis, equal in diameter to the hole *c* of the tonus in the peritreta. Adjoining the under furface of the fquare part were four tenons or teeth, called *autitormi*, *f f*, which entered a circular excavation funk in the furface of the peritreta, around the hole of the tonus, in order to keep the choenicis firm in its place; and in the faid excavation, under the teeth, was an iron plate, to prevent the teeth from penetrating into the wood. On the upper furface of the circular part of the choenicis, a groove *g* was cut diametrically acrofs; and in this groove the epizygis *b b* was laid. One of thefe choenices was applied to each hole of the peritreta, through which the tonus was drawn, the teeth entering the upper furface of the upper peritreta, and the lower furface of the lower peritreta; and then the cords *i i* that formed the tonus were put round the epizygis, as before defcribed in the catapulta; which being done, thofe cords were twifted, by turning the choenicis round with an iron wrench, *Fig. CIII.* having a fquare collar *a b c d*, fitting the fquare part *a a* of the choenicis.

When the choenicis was made of wood, the grain was always to be difpofed perpendicularly; but the epizygis was always made of the ftrongeft iron, becaufe it fuftained the whole power of the tonus. The proportions of the parts of the balifta are here mentioned by Vitruvius, to which the reader is referred, with the caution before given in the explanation of the catapulta: fome information may be drawn therefrom; but experience and trial, as Heron obferves, muft ultimately determine.

The balifta was mounted on a bafe, which is mentioned both by Vitruvius and Heron, but defcribed by neither. This bafe could not be exactly like that of the catapulta, for the different form of this engine would not admit it. Vitruvius, however, mentions feveral of its members by the fame terms he ufed in fpeaking of the bafe of the catapulta.

The balifta was not worked by a fucula, or any other power adjoined to it, as the catapulta was, but by detached powers of various conftructions, differing as the ftrength of the engine or other circumftances required; fome being, as Vitruvius fays, worked with fuculæ and levers, others by fheaves of pulleys, and fome by combinations of wheels and tympanums, placed at convenient diftances and fituations, or fuch as the adjacent ground and objects would admit.

CHAPTER XVII.

Of the Proportions of the Baliftæ.

A BALISTA that is made to throw a ftone of two pounds weight, fhould have a hole in its capitule of V. digits ∵ if for four pounds, VI. digits and VII. digits [1*] ∵ ten pounds, VIII. digits ∵ twenty pounds, X. digits ∵ forty pounds, digits XII. S. K. ∵ fixty pounds, XIII. digits and the eighth part of a digit ∵ eighty pounds, XV. digits ∵ a hundred and twenty pounds, I. foot and S. and a digit and half ∵ a hundred and fixty pounds, II. feet and V. digits ∵ two hundred pounds, II. feet and VI. digits ∵ two hundred and ten pounds, II. feet and digits VII. ∷ two hundred and fifty pounds, [2*] XI. S.

(1*) *Digitorum VI. et digitorum VII.* are the words of the text: but it is fuppofed that the words *fi pondo fex*, if fix pounds, were originally written before *digitorum VII.* and been carelefsly omitted by the copyifts; for in the old Italian editions of Cefariani and Durantino thofe words are inferted.

Perrault, however, fuppofes the words of the text, as at prefent found, to be right; and that they import that the hole may be made of any fize between VI. and VII. digits.

(2*) Here is evidently an error in the text; for a hole fo large as eleven feet and a half could not be required for the weight of 250 pounds, if a hole of two feet and feven digits was fufficient for a weight of 210 pounds. Perrault has tranflated the characters *XI. S. eleven digits and a half*, adding alfo *two feet* without the authority of the text; and which he fuppofes to have been an omiffion. In feveral manufcripts I find the paffage written thus: CCCLX.—I. S. without the word *pondo* between them, as in the printed copies; from whence it feems probable that in the printed copies the X. has been erroneoufly detached from the former number CCCL. and added to the latter, inftead of the I. S. and that it was originally written CCL.—II. S.; fignifying, CCLX. pounds requires a hole of two feet and a half; for in that cafe the diameter of the hole will be one digit larger than the preceding hole, by which it will conform to the rule obferved in the fizes of feveral of the holes foregoing, each of which increafes by a digit.

Philo has alfo given the fizes of the holes proportional to ftones of divers weights: and Buteus has made a calculation of the fame, upon the fuppofition that a ftone of two pounds required a hole of five digits. Thefe authors, however, differ from each other, and from Vitruvius, as the following table will fhew.

A table fhewing the diameter of the hole in digits for ftones of various weights, according to different authors.

Weight of Stone in Pounds or Minæ.	Vitruvius.	Buteo.	Philo.
2	5	5	—
4	6	$6\frac{7}{44}$	—
6	7	—	—
10	8	$8\frac{1}{10}$	11
15	—	—	$12\frac{1}{4}$
16	—	10	—
20	10	—	$14\frac{1}{4}$
30	—	—	$15\frac{1}{4}$
40	$12\frac{9}{16}$	—	—
50	—	—	$19\frac{3}{4}$
54	—	15	—
60	$13\frac{1}{4}$	—	21
80	15	—	—
120	$21\frac{1}{2}$	—	25
128	—	20	—
160	32	—	—
180	37	—	27
200	38	—	—
210	39	—	—
250	40	25	—

Heron gives the following rule for determining the fizes of the holes for ftones of all weights: The number of minæ the ftone weighed, was multiplied by 100, and the cube root of that product extracted, to which root a tenth part thereof was added, which gave the diameter of

When therefore the magnitude of the hole is determined, the ſcutula, which in Greek is called *peritretas*, is deſcribed, of which the length is holes II. F. Z.; the breadth two and a ſixth part. The deſcribed line is divided in half, and when divided the forms of the extremities are contracted, ſo that the oblique formation may have a ſixth part of the length and of the breadth, at the return (verſura) a fourth part. In that part alſo is the curvature in which the points of the angles project, and the holes are turned, and the contractures of the breadth return inwardly a ſixth part: the hole is ſo much oblong as the epizygis is thick. When it is deſcribed, it is divided around ſo that the extremity may have a gentle curvature ∴: the thickneſs of it is S. Γ̄. of a hole. The modiols are made II. :— holes, the breadth I. S. 9. ::: the thickneſs, excluſive of what is inſerted in the hole, is S. I. of a hole; at the extremity alſo the breadth is I. Γ̄. of a hole. The length of the paraſtatæ V. S. Γ̄. holes; the curvature a half part of a hole; the thickneſs, Ū of a hole, and LX. part. At the middle the breadth is enlarged as much as it is near the hole made in the deſcription, in breadth and thickneſs $\overset{u}{\text{V}}$. of a hole, the height IV. parts. The regula which is on the menſa, is in length VI. holes, in breadth and thickneſs half of a hole; the cardo II. Z. :::. The thickneſs of the curvature of the regula Γ. 5. K. The breadth and thickneſs of the exterior regula are the ſame; the length ſo much as is given by the ſame return (verſura) of the formation, and the breadth of the paraſtæ and its curvature K. The ſuperior regulæ are equal to the inferior K. The tranſverſe pieces of the menſa Ū. Ū. K. of a hole. The length of the ſhaft of the climaciclus is XIII. holes ::: the thickneſs III. K.

The breadth of the middle interval is a fourth part of a hole ∴: the thickneſs an eighth part K. The ſuperior part of the climaciclos, which is next to the arms, and which is joined to the menſa, is in the whole length divided into five parts, of which two parts are given to

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the hole in digits: thus a ſtone weighing ten minæ, required the hole to be eleven digits in diameter; for 10 multiplied by 100 produces 1000, the cube root of which is 10; to which adding a tenth part, *viz.* 1, the amount is 11 digits for the diameter of the hole.

But we are not informed for what mina this rule is calculated. The Attic mina contained 100 drachmas, of which the Alexandrian contained 160, and the Roman *pondus* 96; ſo that much depends on the weight of the mina here to be underſtood, and which in following this rule it is highly neceſſary to know. Heron himſelf was of Alexandria; and this rule of his makes the holes much larger for the minæ he means, than Vitruvius allows for an equal number of Roman pounds: theſe reaſons therefore, together with Vitruvius's aſſertion—" that he " has tranſcribed his account from the Greek authors, " but in ſuch a manner as to make it conform to the " Roman weights and meaſures," render it probable that it is the Alexandrian mina on which Heron's rule is founded; and upon this ſuppoſition, allowing alſo for the difference between the Roman and Greek foot, the ſizes of the holes found by this rule will nearly agree with thoſe given by Vitruvius, as well as thoſe of Philo, who ſeems to agree with Heron in uſing the Alexandrian mina.

Another method was alſo uſed by the antients for finding the ſizes of the holes for ſtones of different weights, which was this: Having the ſize of the hole for a ſtone of any weight given, the ſize of the hole for a ſtone of any other weight was found by the method uſed for doubling the cube, i. e. by finding two mean proportionals. It is by this method Buteo has made his calculation.

that member that the Greeks call *chelon* ⁙. The breadth Γ̄. the thickneſs 9. ⁙ the length is III. holes and a half K.; the projecture of the cheles S. of a hole; the plinthigonatos ʒ. of a hole and a ſicilicus; that which is at the axon, called the front tranſverſarius, is three holes ⁙ the breadth of the interior regula Γ̄ of a hole; the thickneſs ʒ. K. The replum of the chelon, which is the cover of the dovetail, is included K. The breadth of the ſhaft of the climaciclus Z. 5.; the thickneſs XII. K. holes. The thickneſs of the ſquare which is at the climaciclus F. 5. of a hole, at the extremities K. The diameter of the round axis is equal to the cheles; that to the clavicula S. is leſs by a ſixteenth part K. The length of the anterides F. III. 9. holes; the breadth at bottom a hole Γ̄. ⁙ at top the thickneſs is Z. K.

The length of the baſe, which is called *eſchara*, is holes ::: the antibaſe is holes IV. ⁙ and both the thickneſs and breadth a hole ::: it is fixed at the half of the height K. The breadth and thickneſs of the column is I. S.; but the height is not proportioned to the holes, being made ſo much as is proper for the purpoſe of the work. The length of the arm ::: is holes VI. ⁙ the thickneſs at the root a hole, and at the extremity F.

I have explained what I have thought moſt uſeful concerning the ſymmetry of the baliſtæ and catapultæ; but I will not omit to deſcribe, as well as I can by writing, the manner of preparing them with the twiſted cords of ſinews and hair.

C H A P T E R XVIII.

Of the Preparation of the Baliſtæ and Catapultæ.

Fig. CIV. BEAMS (*ABCD*) of a ſufficient length are provided, upon which are fixed chelons (*E*), wherein ſuculæ (*F*) are included. At the middle part of the beams excavations (*GHI*) are made, in which excavations the capitules (*KLMN*) of the catapultæ are inſerted, and faſtened in with wedges (*O*), in ſuch a manner that they may not be moved by the diſtenſion. Then the braſs modiols (*P*) are inſerted in the capitule; and in them the

little iron pins (Q), which the Greeks call *epiſchidas*,[1*] are diſpoſed: then the ends of the ropes ($R\ S$) are put through the holes (S) of the capitules, and thrown on the contrary ſide, where, being joined to the ſucula (F), they are wound around it by the levers (T), ſo that the diſtended ropes, when ſtruck by the hand, may on both parts yield an equal ſound; they are then confined at the holes with wedges, that they may not ſlip. On the other ſide likewiſe, being paſſed through in the ſame manner, they are, by the levers and ſuculas, diſtended till they ſound equally. Thus, by the ropes being confined by the wedges, the catapultæ are adjuſted according to the rules of the muſical tones.[2*]

(1*) This word has probably been miſcopied, and ſhould be read *epizygidas*; for it undoubtedly alludes to the *epizygis b b*, *Fig. CII.* which was laid on the modiols or choenices, and which is mentioned by that name in the foregoing chapter.

(2*) This chapter explains the method of forming the tonus or combination of twiſted cords, from whence the power of theſe engines was chiefly derived.

For this purpoſe was uſed the machine *F. CIV.* called by Heron *entonium*. Vitruvius does not fully deſcribe it. The two parallel beams $A\ B\ C\ D$ were connected by the two tranſverſe timbers $U\ U\ V\ V$, forming a rectangular frame, capable of receiving the capitule; the extremities of theſe tranſverſals $U\ U\ V\ V$ paſſed through the parallel beams $A\ B\ C\ D$, and had holes X, in which wedges O being driven, confined the capitule ſecurely between the beams. The ſaid capitule $K\ L\ M\ N$ being then placed between the beams, with the two peritretæ toward the two ſuculæ $F\ F$, and the choenices or modiols P being fixed in the holes, as before deſcribed, one end Q of the cord was faſtened to one of the epizyges, and the other end R carried through both choenices to the fartheſt ſucula $F\ F$, to which it was fixed. The end of another cord S was alſo tied to the other epizygis, and in the ſame manner carried through both choenices to the other ſucula F, and there fixed. Then both the ſuculæ were turned around by the levers T, ſtraining both the cords R and S, till they were diminiſhed in their thickneſs a third part; and (as Vitruvius ſays) till both, upon being ſtruck, yielded tones in uniſon. Wedges were then driven into the choenices, ſo as to ſecure the parts of the cords that were between the two choenices from ſlipping, and to preſerve them in the ſame degree of tenſion. After this, the other parts of the cords were looſened from the ſuculæ; conveyed round the epizyges, through both the choenices, in the ſame manner as before, and faſtened to the oppoſite ſuculæ; by which they were diſtended till they were alſo in the ſame degree of tenſion as the former: and this was repeated till the holes of the choenices were quite filled with the cords, and would admit no more.

When the holes were ſo nearly full that it became difficult to put the cord through them, an iron pin called *ceſtra*, *Fig. CV.* poliſhed and oiled, was driven in to open a paſſage; and then the cord was put through by the help of a poliſhed iron needle called *ramphis*, *Fig. CVI.* having a hole near the point, through which the end of the cord was paſſed; and a knob at the other end, upon which the hammer ſtruck to drive it through.

The cording being completed, ſome of what remained of the cord was tied around the tonus, and the reſt cut off. Then the end of the arm being introduced between the cords, the whole aſſemblage of cords was twiſted, by turning round the choenices with the wrench, *Fig. CIII.* as before explained in the deſcription of the baliſta. For wedging the cord in the choenices, the *periſtomis*, *Fig. CVII.* was uſed; it was a piece of wood about two or three palms long, having a cleft *a* in its ſide, juſt large enough to receive the cord. The periſtomis was laid on the choenicis, and the cord inſerted in the cleft, in which it was ſecured by a wedge *b*. The cord was uſually prepared ready for uſe, and wound around a wooden roller, called *epiſtomis*, *Fig. CVIII.*

Perrault, among many other remarks, obſerves that "it is difficult to comprehend how ropes of eight inches "thick, made of hair, ſhould yield a tone ſenſible to the "human ear." This remark aroſe from his idea of theſe engines: he imagined that it was the whole tonus, or complication of twiſted cords, that yielded the ſound; whereas it was each ſeparate cord of which that tonus conſiſted, as the foregoing account ſufficiently explains. The intention of this was, that every cord of the tonus ſhould be equally diſtended, and that the two hemitones ſhould be equal in power: for if one were ſtronger than the other, the arm it held would recoil quicker, and act upon the miſſile before the other arm arrived; by which means the

C H A P T E R XIX.

Of Machines for Attack, and their Invention.

OF the foregoing things I have ſpoken what I could; it remains now to ſpeak of the machines uſed in attacks, with which generals conquer and defend cities: and firſt of the *Ram*, which is ſaid to have been thus invented:

When the Carthaginians were encamped to beſiege Cadiz, and had taken an advanced fort, which they endeavoured to demoliſh, having no iron tools, they took a beam and ſupporting it with their hands, they drove the end of it repeatedly againſt the top of the wall, throwing down the upper courſe of ſtones; and thus gradually, by courſes, deſtroyed the whole fortreſs. Afterward a certain ſmith of Tyre, named Pephaſmenos, excited by this invention, erected a maſt, from which he ſuſpended another tranſverſely, like a balance; and by drawing it back, and then impelling it forward, with the force of its blows he threw down the walls of Cadiz.[1*]

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dart would be diſcharged by the force of one arm only, and would be diſcharged in an oblique direction.

The cords that formed the tonus were uſually made of the ſinews of animals: thoſe in the legs of deer, and in the necks of bulls, were recommended. But cords made of women's hair were moſt preferred, and accounted the ſtrongeſt.

When by frequent uſe the elaſticity of the tonus was weakened, it was in ſome degree recovered by turning round the choenices with the wrench, in the ſame manner as in the firſt forming it.

The antients had catapultæ and baliſtæ of conſtructions different from thoſe here deſcribed. Bito gives a deſcription of two ſuch engines, and ſays the place, purpoſe, and other circumſtances, often required a difference in their form: Philo alſo mentions many variations and improvements that he had made in the common conſtruction. The catapulta found by Lipſius in the armoury of Bruſſels, although very ſimilar to the ſort above deſcribed, had however many differences, with ſome of the improvements mentioned by Philo. The deſcriptions of Vegetius, and of Marcellinus, who lived many years after Vitruvius, ſhew that, in that interval, the forms as well as names of the military engines had undergone an alteration: thoſe authors call the engine that ſhot arrows and darts *baliſta*, and that which ſhot ſtones *onager*, from the animal of that name, which is ſaid to kick ſtones againſt the hunters who purſue it. Marcellinus alſo ſays the ſame engine was called *ſcorpion*, becauſe, like the inſect of that name, it held its ſting erect.

The power of theſe engines, according to the reports of the antient authors, muſt have been very great: Atheneus relates that a catapul taof only a foot in length was made to ſhoot an arrow half a mile; ſome, it is ſaid, would carry javelins acroſs the Danube. The baliſtæ diſcharged large beams of timber, ſpears of twelve cubits, and ſtones of 360 pounds weight. Polybius makes mention of ſtones being ſhot from baliſtæ to prevent ſhips entering a harbour.

Joſephus records many inſtances of their power—of their beating down the pinnacles and corners of towers, and overthrowing whole ranks of men—indicating a power almoſt equal to that of the modern cannons, which is ſcarcely credible.

(1*) Pliny, b. vii. ch. 56, ſays the *Ram* was invented at Troy; and it is thought it gave riſe to the ſtory of the wooden horſe, by the means of which the city was taken.

Cetras of Chalcedon was the firſt who made the timber baſe, with the wheels under it, and thereon raiſed arrectariæ (upright poſts) and forked yokes, on which he ſuſpended the ram[2*]; covering them with ox hides, that thoſe who were placed in the machine, to batter the walls, might be ſecure. This machine, becauſe it was ſlow in its operation, began to be called the Ram Tortoiſe[3*], and was the firſt example of theſe kinds of machines. Afterward, when Philip the ſon of Amyntas beſieged Byzantium, ſeveral other kinds, more ſimple, were invented by Polydus the Theſſalian; from whom Diades and Chereas, who were in Alexander's wars, received their inſtruction. But Diades in his writings aſſerts to have himſelf invented the moving towers, which he uſed to disjoin, and carry about with the army; as well as the borer, and the aſcending machine, which could be raiſed to the level of the walls; as alſo the demoliſhing crow, which ſome call a crane: he uſed alſo the ram upon wheels, the conſtruction of which he has left in writing.

Fig. CIX. The Tower, he ſays, ought to be made at leaſt LX. cubits high, in breadth XVII. and the contracture at top be a fifth part of the bottom; the arrectariæ of the tower ſhould at the bottom be three quarters of a foot, and at the top half a foot: in this tower, he ſays, may be ten ſtories, with apertures on the ſeveral ſides; but the larger tower *Fig. CX.* ſhould be CXX. cubits high, and of cubits breadth XXIII. S. ⁘ the contracture at top alſo a fifth part ⁘. The arrectariæ ſhould be at bottom one foot, and at top half a foot. In towers of this magnitude, XX. floors are made; each floor having a circuition[4*] of three cubits. It is covered with raw hides, that it may be ſecured from all kind of projectiles.

Fig. CXI. The Ram Tortoiſe is conſtructed upon the ſame principle: it has an interval of XXX. cubits; the height, without the faſtigium (ſlope of the roof), XVI.; the height of the faſtigium, from the ſtratum (the uppermoſt level part) to the top, VII. cubits; alſo out of the middle of the roof a turret not leſs than XII. cubits broad riſes, and therein

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(2*) Atheneus, in his Treatiſe of Machines, aſſerts that Geras, a Carthaginian, was the inventor of the baſe. It has been ſuppoſed that Vitruvius has copied what he has written on this ſubject from Atheneus, or Atheneus from Vitruvius. But the latter expreſsly mentions, at the end of this chapter, that he has copied it from the writings of Diades, from whom perhaps Atheneus alſo copied; for he quotes that author, as Vitruvius alſo does, immediately before his deſcription. Repreſentations of the ram may be ſeen on the arch of Severus, and on the Trajan column, now ſtanding at Rome.

(3*) Vegetius ſays it was ſo called from its reſemblance to a tortoiſe with its head poked out of its ſhell.

(4*) What Vitruvius calls *circuition*, Atheneus calls *peridrome*. Perrault and Galiani ſuppoſe it to ſignify a fence or breaſtwork. Atheneus gives the height of the ſeveral ſtories, which are as follows: The 1ſt, ſeven cubits and a half; the 2d, 3d, 4th, and 5th, five cubits each; and all the reſt four cubits and a half each: the remainder of the meaſure of the height being occupied by the floors, baſe, wheels, and roof.

is raiſed four ſtories in height, in the upper ſtory of which the ſcorpions and catapultas are diſpoſed; in thoſe below a great quantity of water is collected, to extinguiſh fire if it ſhould happen to be thrown therein.

In this alſo was the ram machine, in Greek called *criodoche*, wherein were laid rollers perfectly turned, upon which was diſpoſed the ram; the drawing of which backward and forward with ropes, produced the great effect: this alſo was covered with raw hides, in the ſame manner as the tower.

Fig. CXII. Concerning the Borer he has given theſe rules in writing:—The machine is the ſame as the tortoiſe, having in the middle a ſtraight channel (*A*), like thoſe uſually made in the catapultæ or baliſtæ, of the length of L. cubits, and in height one cubit. In this is fixed a tranſverſe windlaſs (B), and at the end, on the right and left, two trochlea (ſheaves of pulleys), by which the beam, armed with iron at the part (*C*) that lies at the end of the channel, is moved. Under the ſame (beam), included within the channel, are rollers[5*], which cauſe the motion to be quicker and more vehement; and over the beam that is therein are fixed arched ribs (*D*), to bear the raw hides (*E*) with which the machine is covered, to defend the channel.

Of the Crow he has not thought proper to write, becauſe he had obſerved this machine to be of no uſe[6*].

Of the Acceſſus[7*], which in Greek is called *epibathra*, and of the marine machines for

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(5*) In the text it is written *tuti*, which is corrected by De Lact to *tori*: for Atheneus, in this place, writes *cylindroi*; and at the place foregoing, where Vitruvius mentions *torus*, *cylindron*; ſo that, as the ſame thing is expreſſed by Atheneus, it is highly probable that the ſame thing is meant by Vitruvius, in both places; the rather as the correction agrees perfectly with the ſenſe and meaning of the context.

(6*) Apollodorus, Heron, and other antient authors, have deſcribed a machine of this name; and Polybius gives an account of one that was invented by the Romans at the time of their firſt naval engagement againſt the Carthaginians, with which they grappled the enemies ſhips, and by that means chiefly obtained the victory.

(7*) The commentators think the word *acceſſu* ſhould be written *aſcenſu*, ſuppoſing it to ſignify a machine for ſcaling the walls of a town; and Perrault, as well as Galiani, have ſo tranſlated it. But I find it plainly written *acceſſu* in all the manuſcripts I have ſeen: and it is well known that the antients had machines for gaining *acceſs* to the bottom of the walls, in order to undermine them, or fill up the ditches. Julius Cæſar mentions one that he uſed at the ſiege of Marſeilles, called a *muſculus*; and Vitruvius deſcribes one in the following chapter by the name of *teſtudo*, mentioning its uſe by the very words *acceſſus ad murum*. The antients, it is true, had alſo machines for ſcaling the walls; but ſince they had machines for both theſe purpoſes, there is no reaſon to ſuppoſe that the word that clearly expreſſes the one, ſhould have

boarding ſhips, he has only promiſed to treat; for I have not obſerved that he has deſcribed them.

I have mentioned what Diades has written concerning machines, and the manner in which they are prepared. I ſhall now explain ſuch others as appear to me uſeful, according as I have learnt them from authors.

CHAPTER XX.

Of the Teſtudo prepared for filling of Ditches.

Fig. CXIII. THE Teſtudo prepared for the purpoſe of filling ditches, and alſo to gain acceſs to the walls, is thus made :—A baſe (*ABCD*), which the Greeks call *eſchara*, is framed together: it is made ſquare, every ſide having XXV. feet, and four tranſverſe timbers; theſe are connected by two others,[1*] in thickneſs F. S.[2*] in breadth S. The tranſverſe pieces are about a

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been originally written to ſignify the other. All the reaſon I can learn for this ſuppoſition of the commentators, is, that they believe it to be the ſame machine that Vitruvius has before mentioned in this chapter, by the words *aſcendentem machinam*; and they alſo ſuppoſe it to be the ſignification of the term *epibathra*, which Vitruvius ſays was the Greek name of the machine: but, at the 21ſt chapter following, Vitruvius uſes the word *arca*, which ſignifies ſome kind of incloſure, or ſhelter, or fence, for what Atheneus, in deſcribing the ſame object, calls *epibathra*. This therefore argues that that Greek word does not ſignify any kind of aſcending machine, as ſuppoſed, but ſome kind of teſtudo, or incloſed machine: and as Vitruvius here applies that word to the machine in queſtion, this, conjointly with the agreement of all the manuſcripts and editions of the text, amounts almoſt to a proof that the word *acceſſus* is in this place the original word, and that it ſignifies ſome kind of teſtudo or muſculus; not a ſcaling machine, as generally beleived.

(1*) This deſcription is not very intelligible; I have ſhewn my conception of it in *Fig. CXIII.* But Perrault and I underſtand it differently. The four tranſverſe timbers on every ſide, I ſuppoſe to mean the two inner and the two outer timbers which lie tranſverſely to the ſpectator, on whichſoever ſide he views the ſquare: the two other timbers, ſaid to connect them, I imagine to be diagonal pieces *EH* and *GF*; for ſuch diagonal pieces, though not particularly mentioned, are highly proper, and almoſt indiſpenſable, to preſerve ſuch a baſe, when in motion, in its true rectangular poſition. Apollodorus alſo, in the deſcription of the teſtudo, mentions ſuch diagonal timbers.

(2*) Meibonius thinks theſe characters F. S. ſhould be F. Z. becauſe the character ſignifying the greater proportion was uſually placed the firſt; Z. according to him ſignifying $\frac{4}{16}$, and F. $\frac{10}{16}$, whereas S. is univerſally allowed to ſignify $\frac{1}{2}$. But ſuch dimenſions appear to be too ſmall for timbers of the length deſcribed, and ſcarcely ſufficient to ſuſtain their own weight without bending in the middle; for which reaſon it is probable that the characters have been falſified and miſcopied. It is not unlikely that the text may have been originally written *craſſis I. S. latis I. S.* the *I* in the former being changed to an *F*, and

foot and S. asunder; and in their intervals (*II*) are placed *arbusculæ*, called in Greek *amaxopodes*,[3*] within which the axes of the wheels, armed with iron plates, turn: and these arbusculæ are prepared with turning joints, and have holes through which are passed levers to move them round; so that, by turning the arbusculæ, the machine may be moved forward or backward, to the right or left, or obliquely to the angles, according as the work may require. Upon the base two beams (*KK*, *LL*) are laid, projecting on both sides six feet; near the projecting ends of which, two other beams (*M*, *N*) are fixed, projecting before the fronts seven feet, as thick and broad as those in the base.[4*] Upon this frame-work are erected the connected posts (*Q*), being, exclusive of the tenons, IX. feet in measure, one foot and a palm on every side; and being at intervals (*R*) of a foot and a half:[5*] these are secured at the top by the mortised beams (*S*). Upon the beams are placed the capriols[6*] (*T*), mortised and

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in the latter omitted; for a foot and a half in breadth and thickness would not have been more than sufficient for timbers of their length and purpose.

Perrault has interpreted F. S. the eighteenth part of the length of the timbers; by which he makes their thickness a little more than a foot and one third, which is a measure certainly more suitable: but on what authority he has done this, does not appear; for in the next chapter he has given F. the value he usually allows it, *viz.* the $\frac{1}{12}$ of a foot, translating F. Z. the $\frac{1}{11}$ and the $\frac{1}{5}$ of a foot.

(3*) The *arbusculæ*, because the word signifies *little trees*, are generally supposed to have been cylindric pieces of timber, having a cleft at the bottom to admit the wheel. But, at the following chapter, the wheels that were set in the arbusculæ are said to have been three feet thick, and nearly seven feet in diameter: it must have been an uncommonly large and enormous tree to have been of sufficient diameter to receive such a wheel within its body; and also to have substance enough left on each side to receive the axis of the wheel, and consequently to support the weight of the whole machine, as well as its lateral pressure when in motion.

Trees of such a magnitude could not always be procured; and, if they could, it would not be expedient or mechanical to use such a solid mass of timber, when a frame of the size required would answer the purpose better, as being lighter, more manageable, and equally strong. For these reasons I am compelled to differ from former commentators in my idea of the arbusculæ. I have shewn my idea by *Fig. CXIV.* It consists of a square horizontal frame *AB*, having on the right and left sides perpendicular pieces *F*, secured by braces *G*: these include the wheel *H*, and receive its axis.

In the middle of the frame is a perpendicular column or tree *C*, being quadrangular at the part *D* that enters the frame, and cylindrical above: this cylindrical part passes upward into the testudo, through the circular intervals *II*, *Fig. CXIII.*; so that, by inserting levers *E* in holes bored in the cylindric part, the arbusculæ might be turned by the men in the testudo to the direction required.

The arbusculæ and wheels were defended from the power of the missiles by the sides of the testudo projecting before them, as Vitruvius presently mentions.

Perrault observes that this was a necessary precaution; and relates that, at the siege of Ostend, an engineer made a machine in imitation of the testudo of the antients, which, for want of such defence, was soon rendered useless, a cannon-ball breaking one of the wheels: nevertheless Perrault has represented the wheels exposed in the draught of all the machines he has given.

(4*) There must be yet two more beams *OP*, which Vitruvius does not mention; these must lie on, or be framed into, the projecting ends *V* of the latter two beams *MN*, to support the posts on those sides of the testudo; for all the four sides projected several feet before the front of the base, in order to defend the wheels, and the men who worked them, from the missiles of the enemy, as before observed.

(5*) In Galiani's translation this is inadvertently written *mezzo piede*, half a foot—instead of *un piede & mezzo*, a foot and a half—and it is not corrected in the errata.

(6*) *Capriols* here signify what are before called *cantheri*, being the rafters or timbers that form the inclined sides of the roof.

tenonted one into the other, riſing in height IX. feet. On the capriols is laid a ſquare beam (*U*), by which the capriols are connected: they alſo are ſecured with lateraria[7*] fixed all over them, and are covered with planks of the palm-tree; or, if not of that, of ſome other wood that has the proper qualities: excluding, however, pine or alder; for theſe are weak, and eaſily take fire. All over the planking[8*] are laid gratings, made of ſlender twigs, thickly interwoven together, and being green. Then with doubled raw hides ſewed together, and ſtuffed with ſea-weeds, or ſtraw macerated in vinegar, the whole machine is covered over; ſo that it may be ſecured againſt the attacks of the baliſtæ, and the effects of the firebrands.

CHAPTER XXI.

Of other Kinds of Teſtudos.

Fig. CXV. THERE is another kind of Teſtudo, that has all the parts the ſame as that before deſcribed, except the capriols; inſtead of which it has all round it a parapet, and pinnæ[1*] (*A*) made of boards; and at the top declining eaves (*B*), firmly connected by means of boards, and ſkins fixed thereon. Upon theſe alſo clay mixed with hair is laid, to ſuch a thickneſs as may prevent the machine from being endangered by fire. Theſe machines may have eight wheels, if the nature of the place will admit it to be ſo prepared.

Fig. CXVI. Thoſe Teſtudos that are made for undermining, are called in Greek *oryges*; they are the ſame as thoſe above written, excepting that their fronts are formed like equilateral triangles (*A B C*), that the miſſiles from the walls that are ſhot againſt them may not be received on a flat front, but be ſlanted off ſideways, that the diggers who are within may be ſecured from danger.

(7*) Theſe *lateraria* are mentioned again in the next chapter; they were, very likely, *planks* fixed tranſverſely on the rafters of the roof.

(8*) Perrault has tranſlated "tabulata," *les coſtes*, i. e. *the ſides*; becauſe he ſays *that word ſignifies a floor, which the teſtudo had not*: but it here evidently means the planks or boards with which the capriols were covered.

(1*) The *pinnæ* here probably mean what we call *battlements*.

Fig. CXVII. It feems to me alfo not improper to fpeak of the Teftudo that Agetor[2*] the Byzantine made, and the manner in which it was conftructed. The bafe (*ABCD*) was in length LX. feet, in breadth XVIII.[3*] The four *arrectaria*[4*] (*E*) that were placed on the frame, were formed out of two beams, each being in height XXXVI. feet, in thicknefs a foot and a palm, and in breadth a foot and a half. The bafe had eight wheels (*FF*), upon which it was moved; their height was VI. S: —[5*] feet, their thicknefs three feet; and were thus made out of triple timbers united one to the other with dovetails, and fecured with iron plates cold-worked. Thefe had a rotation in arbufculæ, or, as they are called, *amaxopodes*.

Upon the plane (*HIKL*) of the trantræ, or *tranfverfe beams* (*GG*), that were laid on the bafe, were erected pofts (*M*) of XVIII : — feet; being in breadth : — S. in thicknefs F. Z. diftant from each other I. S : —[6*]. Over thefe were the circumcluding beams (*N*) that con-

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(2*) Written in fome manufcripts *Hector*, and *Hegetor*.

(3*) Atheneus and Heron, who defcribe this teftudo of Agetor, fay the length of the bafe was 42 cubits, and the breadth 28 cubits: fo that the length Vitruvius mentions, *viz.* LX. feet, may be right; for as the Greek foot was about $\frac{1}{24}$, or half an inch, fhorter than the Roman foot, 42 cubits will make about 60 feet 5 inches and a half of Roman meafure. But the latter number in Vitruvius (XVIII.) may probably be erroneous, as it feems too fmall for the ufe the teftudo was to ferve; and that meafure in which both Atheneus and Heron agree, *viz.* 28 cubits, is probably the right.

(4*) Where thefe four *arrectaria* were placed, or what purpofe they ferved, is not explained: they did not fupport the roof; for others, XVIII. feet high, are hereafter allotted to that office. It is not mentioned whether the two beams from which they were formed were joined together fide by fide, or at their ends, forming together a poft of about 72 feet in length. But I am induced to determine, from many circumftances, for the latter; and that they were the pofts *EE*, *Fig. CXVII.*

There are many other parts of this teftudo that are not fufficiently explained, fo that it becomes difficult to conceive its entire conftruction; and the tranflators have omitted giving any delineation of it.

Atheneus defcribes it, but almoft as obfcurely as Vitruvius. A ram is hereafter mentioned; but it is not faid whether or not it was united with the teftudo, or where or how it was difpofed. Rams, when joined to teftudos, were ufually placed within them, that the men who worked the ram might be fheltered and defended by the roof of the teftudo. But this ram could not be fo difpofed—1ft, becaufe the timbers that fupported it are defcribed to be feveral feet higher than the roof of the teftudo: and, 2dly, if fo fituated, it could not reach to batter the wall fo high, or fo far fideways, as is mentioned; for the breadth and height of the teftudo would not admit it. Thefe were fome, among many other difficulties, that impeded the conception. But the fketch annexed to Heron's defcription, in which the ram appears to be fufpended above the roof of the teftudo, although it is not fo expreffed in the defcription, contributed to form the idea.

(5*) Perrault has interpreted the characters VI. S: — five feet and three quarters. They evidently fignify fix feet, and the portion meant by the mark S: —, which is generally believed to fignify three quarters of the foot, the integer named. Atheneus fays they were four cubits and a half, which equals fix feet and three quarters exactly.

(6*) Atheneus fays thefe pofts were twelve cubits long, three palms in breadth, and ten digits in thicknefs, and diftant from each other feven palms; fo that he agrees with Vitruvius in all the meafures except the length, which Vitruvius makes more by the character : —. But as that meafure is written differently in different manufcripts of Vitruvius, that of Atheneus is more to be depended on. This agreement however of the two authors, in all the other meafures, confirms the opinion that the character S : —, or : — S, fignifies three quarters of the integer named; S. fignifying a half, and : — a quarter: but it entirely difproves the ufual acceptation of the characters F. Z. which have been fuppofed to fignify $\frac{1}{16}$ and $\frac{1}{4}$ of a foot, that is, two inches and a half; a meafure

nected the whole frame [7*] ::: being I : — foot broad, and S : — thick. Upon this the capriols (*O*) were raised in height XII. feet. On the capriols a beam (*P*) was laid, that united the framing of the capriols. They had also lateraria [8*] fixed transversely, the boarding upon which covered all the inferior parts. It had likewise a middle floor, supported upon little beams, wherein the scorpions and catapultas were placed. [9*] And two compact arrectaria (*Q*) were erected, being in height feet XXXV. [10*] ⁘ in thickness a foot and a half ⁘ in breadth II. feet, conjoined at their tops with a transverse mortised beam (*R*), and with another (*S*) tenonted in the middle between the two shafts, and fastened with iron plates. There was moreover placed a moveable timber, laid across within the shafts and the transverse piece, firmly held by chelonia and ancons. [11*] In this timber were two turned axles, from which the ropes (*T*) supported the ram (*UV*). Above the top of these, that supported the ram, [12*] was placed a *plu-*

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much too small for the thickness of the posts, which Atheneus says was ten digits, or seven inches and a half. These characters F. Z. therefore agree with the explication of Meibonius, given in the table of characters at the 15th chapter foregoing.

(7*) The marks ::: and ⁘, in several places of this and other chapters, appear to be not used as the sign of any number or measure, but rather as stops or periods of the discourse. Perrault however has thought differently, and has invariably translated them as signifying the fraction $\frac{1}{9}$ of the integer, wherever they have occurred. I have endeavoured to keep them in the translation in the same situation as in the original, which is the reason the name of the integer is sometimes placed before the number, or character, instead of being after it.

(8*) The *lateraria* are explained in the foregoing chapter.

(9*) Atheneus says this middle floor was placed upon the circumcluding beams before mentioned, which he calls *epistylia*.

(10*) The height of these *arrectaria*, according to Atheneus, was thirty cubits, equal to XXXXV. feet; it may therefore have been originally written XXXXV. by Vitruvius, and the copyists have omitted an X.

But in the breadth of these arrectaria Atheneus is probably wrong; for he makes it but three palms, although he agrees with Vitruvius in the thickness being a foot and a half: and as it is not likely that that measure of the timber which is called its breadth should be less than that which is called its thickness, I am induced to think that Atheneus may be, in this place, corrupted. Vitruvius does not inform us where these arrectaria were raised; but Atheneus says it was in the middle of the testudo.

(11*) "Quo insuper collocata erat alternis materies "inter scapos et transversarium trajecta." The words *alternis materies* have been rendered by the translators *alternate timbers*; but the preceding word *erat*, plainly indicates that they relate to a single object: and this is confirmed by Atheneus, who mentions it as a single piece of timber; so that the word *alternis* must here signify that the said piece was moveable, and could be placed alternately in different situations, higher or lower; thus raising or lowering the ram, which was suspended thereto. Perrault's idea of two ranges of holes, like those in the frames for embroidery, seems totally inapplicable, and unauthorized by the text.

This moveable timber is said to have been placed between the shafts and transverse piece; which, as Perrault observes, is not possible, because those two parts join: but the meaning (in my idea) is, that the said moveable timber was placed within the space circumcluded by the shafts and transverse piece; the word *inter* being sometimes used by Vitruvius in that sense, as was before noticed at the 6th chapter of the 8th book.

(12*) "Supra caput eorum qui continebant collocatum "erat pluteum." These words have also been generally rendered, "Over the head of those who managed the ram, "was placed a pluteum:" but Atheneus says it was placed above the *criodoke*, or beam that supported the ram; and Heron's sketch and words describe it to be upon the top of the front of the tower. The word *eorum* therefore

teum (*W*), fashioned like a little tower, wherein two soldiers could, without danger, stand to observe and give notice of the enemies attempts. The length of the ram was feet CVI. ::: the breadth at bottom, a foot and a palm ::: the thickness a foot [13*] :::. It was diminished at the head, being in breadth I. foot ::: and in thickness S. :—. This ram had also a rostrum (*V*) of hardened iron, such as war ships usually have; and from this rostrum extended four iron bars (*Y*) about fifteen feet,[14*] which were fixed to the timber: from the head also to the lower end of the beam were stretched four ropes, eight digits in thickness, bound in the same manner as the mast of a ship is bound from the poop to the prow;[15*] and these ropes were fastened with transversal ropes, a foot and a palm distant from each other,[16*] and then the whole ram was covered with raw hides: also at the upper ends (*T*) of the ropes by which it was suspended,[17*] were four iron chains, and these were also covered with raw hides.

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must allude to the axles (that supported the ram) which Vitruvius has just mentioned, and not to the men who worked the ram; for, should the pluteum have been placed just over those men's heads, it must have been an impediment to the ram's motion.

(13*) As Atheneus says the thickness of the ram was two feet, Meibonius supposes that, instead of *crassitudine pedali*, Vitruvius wrote *crassitudine bipedali*. But Heron agrees with Vitruvius in allowing the thickness but one foot: and all these authors agree in its measure at the head; where, according to Heron and Vitruvius, it was diminished a quarter of a foot in breadth and thickness. This therefore, together with the impropriety of expressing the thickness to be greater than the breadth, renders it probable that the error is not in Vitruvius, but in Atheneus.

Both Heron and Atheneus say the length of the ram was 120 cubits.

(14*) "Ex ipso rostro laminæ ferreæ quatuor circiter "pedum XV."

Perrault has translated this passage thus: "From the "said head proceed four plates of iron, about four feet "long." And by his notes it appears that he has supposed the word *quatuor* to relate to *pedum*, making the numerals *XV.* to signify $\frac{1}{15}$ of a foot more: so that he seems not to have been aware that he has used the same word *quatuor* twice in the same sentence; for he has applied it first to *laminæ ferreæ*, saying *four iron plates*; and then again to *pedum*, saying *four feet*.

Galiani notices Perrault's improper application of the word *quatuor* to *pedum*; but has not observed that he has used it twice, by applying it also to *laminæ ferreæ*. As it has been the constant practice of Vitruvius throughout the whole work, and often repeated in this chapter, to express the quantity or number by numeral letters placed after the name of the integer, there can be no reason to doubt that in this instance (which is analogous to all the rest) he follows the same method.

These numerals *XV.* therefore undoubtedly relate to *pedum*, and express the number of feet the iron bars were in length; as *quatuor* does to *laminæ ferreæ*, to denote the number of those iron bars: and, to confirm this, both Atheneus and Heron agree in expressing the number of the iron bars to be four; and their length to be ten cubits, which is XV. feet exactly.

(15*) This passage excites an idea that the ropes extended from the top of the arrectaria to each end of the ram, the two ends of which answering to the poop and prow of the vessel, and the arrectaria to the mast. But the words of Heron and Atheneus do not encourage such an idea; they only import that the ram was girt around with the ropes, which, according to them, were in number *three*, although Vitruvius writes *four*.

(16*) Atheneus and Heron describe these transversal bands to be applied only at the middle part of the ram, and the number of them to be four; so forming three intervals, from which the four ropes *TX*, that supported the ram, extended up to the turned axles before named at the top of the arrectaria: thus having some resemblance to the manner in which the mast of a ship is bound from head to stern.

(17*) Vitruvius has not clearly expressed what ropes he here means; but we learn from Atheneus that they were the ropes *TX* that hung down from the before-named axles, and supported the ram. Atheneus adds, that the chains with which the tops of them were bound were covered with raw hides, so that they could not be seen.

The projecture of it had a compact and fixed area of boards, with large ropes extended; the roughness of which preventing the feet from slipping, it was more easily brought to the wall.[18*] This machine could be moved in six manners: progressively, also to the right and left sides; by means of its extension it could be raised upward, and declined downward.[19*] The machine could be elevated, to demolish a wall, about an C. feet in height[20*]; it also could reach to the right and left sides not less than an C. feet: it was managed by an C. men; and had the weight of four thousand talents, which is equal to CCCCLXXX. (thousand) pounds.[21*]

(18*) It is uncertain what part is meant by the *projectura*, which Atheneus calls *prosphora*, whereon the arca, or inclosure of boards, was fixed. By Heron's sketch it should seem to be the projecting end of the ram itself; for the large ropes (or net, *a*, *b*, as Heron and Atheneus call it) appear to hang therefrom. But the projecting end of the ram itself seems a very improper place for an inclosure of boards to be fixed on; as the concussive motion of the ram must shake it to pieces, how strongly soever it might be connected. I cannot satisfy myself with any conjecture concerning it; but am most inclined to believe the *projectura* to have been a kind of draw-bridge, united to some part of the testudo: for such bridges were not uncommon in this kind of machines; they being kept in a perpendicular situation against the sides of the testudo or tower till wanted, when they were let down by ropes, so as to project in a horizontal position on to the enemies walls, as soon as a breach had been made therein by the battering ram.

On such a bridge the arca of boards might have been disposed, to shelter the men, when crossing thereon to the walls of the enemy.

(19*) The text says "this machine was moveable in "*six manners*:" but Perrault translates it, *three manners*; for he supposes the number to have been written in numerals thus *III.* and that the copyists have mistaken it for *VI.* But I find it expressed by the word *sex* in all the manuscripts and printed copies I have examined, and therefore not likely to have been so altered. Atheneus also agrees with Vitruvius in this circumstance, and specifies the six movements thus: 1st, *forward*; 2d, *backward*; 3d and 4th, *to both sides*; 5th, *upward*; and 6th, *downward*.

These perhaps may not be admitted to be more than three distinct movements; but they may have been six in the idea of Vitruvius, to whose idea it is proper that the explanation should conform.

(20*) At this place also Perrault believes there is an error. It is said the "ram could be elevated, to demolish "a wall, to an hundred feet in height." This height Perrault thinks the ram could not reach, the testudo under which it was placed not being a third of that height. Nevertheless, Vitruvius's words are confirmed by both Heron and Atheneus; so that it is not probable that the text is here erroneous. There is a reason for the ram being able to reach so high, that Perrault seems not to have had an idea of; which is, that it was suspended above the roof of the testudo, not within it, as he supposes. There may be another reason also, not explained by Vitruvius: this is, that the ropes that supported the ram might not be fixed exactly at the middle of it, but nearer to its end, where, for a counterpoise, was fixed a great weight *U*; this being a method usually practised, as Apollodorus asserts: by these means the ram would not only reach to a greater distance and height, but also its momentum would be considerably increased.

(21*) In writing these numerals CCCCLXXX. it is supposed the copyists have omitted the line over them, placed thus $\overline{\text{CCCCLXXX}}$. which was a mark the antients used to signify thousands; the numbers it was applied to then expressing as many thousands as without it they signified units: for the talent, although it differed in different countries, was however in some countries reckoned at 120 pounds; at which rate 4000 talents equal 480,000 pounds.

In one of the manuscripts at the British Museum the numerals are really written with the line over them.

I

CHAPTER XXII.

Of Things relative to Defence.

OF the Scorpions, Catapultæ, and Baliſtæ, as alſo of Tortoiſes and Towers, by whom they were invented, and how they ſhould be conſtructed, I have diſcourſed ſo far as appeared to me proper. But of the Scalæ (ladders) and Carcheſia[1*], and thoſe things of which the principles are more ſimple, it is not neceſſary to write; for theſe the ſoldiers themſelves uſually make. Nor can they in all places be *of the ſame conſtruction; becauſe fortifications from* fortifications, and the courage of nations, are different: ſome machines ſhould be ſuited to the bold and daring, others to the diligent, and others again to the timid. Whoever therefore will attend to theſe precepts, ſelecting from their variety, and combining them together in one compoſition, will not want other aſſiſtance; but whatever the caſe, or the circumſtances, or the nature of the place may require, he will without doubt be able to perform.

Of defenſive machines it is not poſſible to give an explication in writing: for the enemy make not their military weapons like ours; and their devices are oftentimes, by a ſudden ingenious thought, without machines, fruſtrated. Thus it is reported to have happened with the Rhodians. Diognetus was a Rhodian architect, who was paid a fixed annual ſalary from the public, to honour him for his ſkill. At that time a certain architect from Aradus, named Callias, arrived at Rhodes, obtained an audience, and produced a model of a wall, with a machine in a verſatile carcheſium fixed thereon, by which he could ſeize an *helepolis*[2*] approaching the fortification, and transfer it within the walls. When the Rhodians ſaw this model, in their admiration they took from Diognetus his eſtabliſhed ſalary, and conferred that honour upon Callias.

About that time king Demetrius, who for his firmneſs of mind was called Poliorcetes[3*], preparing for war againſt Rhodes, took with him Epimachus, a famous Athenian architect, who with great labour, and at an immenſe expence, prepared an helepolis, whoſe height was

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(1*) The carcheſia are ſpoken of at the fifth chapter foregoing.

(2*) Signifying a machine for the attack of cities.

(3*) A city-beſieger. The hiſtorians ſay Demetrius was ſo called from the number of cities he beſieged, and from his perſevering in the ſiege till he had conquered.

CXXV. feet, and breadth LX feet[4*]; which he ſo ſecured with hair-cloths and raw hides, that it could withſtand the blow of a ſtone, ſhot from a baliſta, of CCCLX. pounds. The machine itſelf was (in weight) CCCLX. thouſand pounds. When Callias was required by the Rhodians to prepare his machine againſt this helepolis, and transfer it, as he had promiſed, within the walls, he declared he could not: for all machines cannot be formed upon the ſame principles; and there are ſome that have effects in models, the like of which in the large cannot be produced; and others cannot admit of any model, but muſt be themſelves executed: ſome alſo there are that in models appear very ſpecious, but when executed at large are uſeleſs, as we may obſerve by this inſtance. So a hole of half a digit, a digit, or even a digit and a half, may be bored; but if by the ſame means we would make one of a palm, it is not to be done; one of half a foot or more ſeems not even to be thought of: ſo that what in ſmall works appears poſſible, in very great is found to be impracticable; much leſs can the ſame methods be practiſed in yet greater works. When the Rhodians, who had done this injury and diſhonour to Diognetus, perceived that they were by theſe principles deceived; and ſaw the enemy determined to inveſt them, and the machine prepared to take the city; dreading the danger of ſlavery, and expecting nothing but the deſtruction of their town, they humbled themſelves to Diognetus, entreating him to aſſiſt his country. This at firſt he refuſed; but afterward, when the delicate virgins and youths, accompanied with the prieſts, came to ſolicit him, he then promiſed it, upon theſe conditions—that, if he took this machine, it ſhould be his own. This being agreed to, he broke through that part of the wall to which the machine approached; and ordered all the people, public and private, to pour through channels made in this aperture whatever water, dung, or mud they had, before the wall. In the night a great quantity of water, mud, and dung being there diſcharged, on the following day, when the helepolis approaching came near to the wall, it ſunk in this humid quagmire; nor could it afterward be moved forward or backward. When therefore Demetrius ſaw himſelf overreached by the ſagacity of Diognetus, he with his fleet departed. The Rhodians then, delivered from the perils of war by the ingenuity of Diognetus, returned him thanks in public, and beſtowed on him all (kinds of) honours, and ornaments of diſtinction. Diognetus then brought the helepolis into the city, ſituated it in a public place, and thus inſcribed it:—*Diognetus gave this preſent to the people, out of the ſpoils of war.*

(4*) Plutarch, in the life of Demetrius, deſcribes this *helepolis* to have been a ſquare tower, diminiſhing toward the top, being 48 cubits broad, and 90 in height; containing nine ſtories, and moveable upon wheels. It may have been a tower of that kind that contained a ram in the lower part, deſcribed by Vitruvius in the 19th chapter of this book.

Thus, for defenſive purpoſes, we may obſerve it is not ſo much machines as ſtratagems that are to be made uſe of. So at Chios, when the enemy had prepared their *ſambucæ* [5*] on board their ſhips, the Chians in the night threw earth, ſand, and ſtones, into the ſea, before the wall; ſo that, when they attempted to approach it the following day, the ſhips grounded upon the heap that was under the water, and could neither approach the wall nor return back, but were with flaming *malleoli* [6*] there conſumed.

At Apollonia alſo, when it was beſieged, and the enemy by digging a mine thought to enter the fortifications without ſuſpicion, the Apollonians, being apprized of it by their ſpies, were diſordered by fear at the news, were weak in their councils, and confuſed in their minds; for they knew not at what time or place the enemy would enter. Then Tryphon of Alexandria, who was the architect there, marked out many caverns within the walls, and digging out the earth, proceeded without the wall as far as the ſhot of an arrow, where in all of them he ſuſpended braſs vaſes: in one of theſe caverns, that was oppoſite to the mine of the enemy, the ſuſpended vaſe began to ſound at the blows of the iron tools; and by this it was known at what part the enemy were working the mine, and intended to penetrate. The ſituation being thus diſcovered, he prepared caldrons of boiling water and pitch, with human dung, and heated ſand, in a place that was over the heads of the enemy: then in the night boring a number of holes, through theſe he ſuddenly poured the mixture; and thus deſtroyed all the men who were at work in the mine.

When Marſeilles likewiſe was beſieged, and there were upwards of thirty mines dug, the inhabitants ſuſpecting it, ſunk the ditch before the wall deeper, ſo that all the mines terminated in the ditch. But, in the places where there was no ditch, they dug a pond within the walls, very long and broad, like a fiſh-pond, oppoſite to the mine, filling it from wells or from the port. As ſoon therefore as holes were opened, the water ruſhing in with great

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(5*) Machines to ſcale the walls; ſo called from being ſhaped like the muſical inſtrument of that name, ſpoken of at the 1ſt chapter of the 6th book, where it is ſignified to be of a triangular figure. Vegetius, l. iv. ch. 21, ſays, "This machine is ſo called from its ſimilitude to a cythara; "for as the ſtrings are diſpoſed in a cythara, ſo are the "ropes in the beam that is put againſt the tower, the "beam having pulleys at the upper part." It is probable therefore that this machine was a ladder, narrow at the top, and broad at the bottom; the ſteps of which were formed of ropes, that were connected by other perpendicular ropes on each ſide, paſſing round the pulleys at the top, and by that means being drawn up. Plutarch ſays, Marcellus was the inventor of the ſambuca.

(6*) Theſe *malleoli* were arrows, having combuſtible compoſitions fixed to them; they were ſhot againſt the objects they wanted to burn.

The combuſtible compound uſed was in aftertimes called the Greek fire; which burnt ſo intenſely, that it is ſaid it could not be extinguiſhed but by vinegar mixed with ſand and urine.

violence, threw down the props; ſo that all who were therein were overwhelmed by the quantity of water, and ruins of the mine.—When a rampart alſo had been prepared with trunks of trees oppoſite to their walls, they, by throwing againſt it from their baliſtæ red-hot iron bars, conſumed the whole. And when the ram tortoiſe approached to batter their wall, they let down a rope with a nooſe to it, and with this bridled the ram: then, winding the rope round a wheel by means of a capſtan, they held its head ſuſpended, ſo that it could not touch the wall; and at laſt, with burning malleoli ſhot from the baliſtæ, they deſtroyed the whole machine. Thus theſe cities obtained the victory, and were preſerved, not by the help of machines, but by the ſkill of their architects oppoſed to the power of machines.

Of the conſtruction of ſuch machines for peace and war as I have judged the moſt uſeful, I have, as well as I have been able, treated in this book; and I have, in the preceding nine, diſcourſed of the ſeveral other parts of architecture: ſo that the whole work might, in ten books, explain all the branches of the art.

THE END.

A P P E N D I X.

BOOK II. Ch. III. IN my tranflation of the paffage of Vitruvius concerning the fize of the Roman bricks called *didoron*, I followed the text of the common printed editions, as all former tranflators have done. Since, upon obferving the proportions given by Pliny to be very different, I have been induced to confult the manufcripts; and, in all I had opportunity to examine, I found the fize to be the fame as that reported by Pliny, and different from that given in all the printed editions. In the editions they are faid to be one foot long, and half a foot broad; in the manufcripts, one foot and a half long, and one foot broad. Inftead alfo of the name *didoron*, the manufcripts have it *lydium*; not *lichum*, as Philander reads it (probably by the femblance of the letters). The paffage in the manufcripts runs thus:—Fiunt autem laterum genera tria: unum quod Græcè *lydium* appellatur, id eft quo noftri utuntur, longum fefquipede, latum pede.

This meafure of the Roman bricks agrees with many which remain (allowance being made for the different fhrinking of different earths) as in the Portico of Octavia, and other ruins at Rome, and in fome remains of Roman buildings in this ifland. (See Archæologia, vol. iv. p. 88.) The fame fize is alfo allowed them by Alberti in his treatife of Architecture, book ii. ch. x.; by the anonymous antient author in Polenis Exercitationes Vitruvianæ; and by Grapaldi De Partibus Ædium: this latter fays the bricks were called *lydoron*, or *didoron*. The Vatican manufcripts quoted by Galiani agree likewife in the fame meafure.

But the term *didoron*, which fignifies *two palms*, does not feem applicable to bricks that were a foot and half, or fix palms, long: to make it apply, fome commentators have alleged that the major palm of ¾ of a foot is to be underftood in this kind of bricks. But it appears not fatisfactory that we fhould underftand the fame term *doron* to fignify in one kind the major palm, and in the other kinds the minor palm; and that the kind called the two palm bricks fhould be larger than thofe called the four and five palm bricks.

The letters of the antient manufcripts are very eafily miftaken, and the words are thus converted into others: if we might fuppofe that *lydoron*, according to Grapaldi, was originally written, or rather *polydoron*, many palms, the two firft letters being carelefsly omitted, the term would then well agree with the kind of bricks defcribed by it.

From the foregoing obfervations, I am for altering the paffage of my tranflation in queftion, thus: inftead of *a foot long, and half a foot broad*, read *a foot and half long, and a foot broad*; and inftead of *didoron* read *lydoron* or *polydoron*.

Pliny alfo differs from Vitruvius in the fize of the bricks called *tetradoron* and *pentadoron*, which the latter defcribes as being fquare; whereas the former fays, all the kinds of bricks were of the fame breadth, and differed only in their length.

N. B. Note (2) of this chapter, fo far as it regards the fizes of the bricks, will require to be corrected in confequence of thefe obfervations.

There are ſeveral paſſages in this and other chapters which indicate that the bricks ſpoken of were not burnt, but dried only. Vitruvius mentions the ſtraw uſed in them not adhering in ſome kinds of earth; of their ſhrinking after they are laid in the building, if the inſide be not ſufficiently dried; and of their requiring at leaſt two years to dry: and at Chapter VIII. he ſays, the tops of the walls ſhould be covered with teſtaceous ſubſtances, to prevent the rain, if it ſhould penetrate through the roof, from injuring the bricks in the wall. The teſtaceous ſubſtance meant was probably ſome kind of burnt earth, as obſerved at note (8) of that chapter: and, if the bricks were alſo burnt, there could be no reaſon for the caution, ſince the rain could no more injure one than the other. The non-adheſion of the ſtraw could not be mentioned in burnt bricks; nor the being dry without ſide, and not within; and ſhrinking, from that cauſe, after they were laid in the wall. It ſeems probable therefore that the antients, ſometimes at leaſt, uſed unburnt bricks, perhaps in the ſmaller houſes of private citizens; and theſe are what Vitruvius means by the word *later*, diſtinguiſhing the burnt ſort by the term *teſta*, or *later coctus*.

BOOK III. Ch. III. Note (15). It is in this note obſerved, that ſome commentators have judged that Vitruvius preſcribes too large a proportion for the receſs of the cathetal line from the extremity of the abacus of the Ionic capital, and have therefore thought his text was corrupted; but, in proof of its purity, there are remains of ancient Greek buildings ſtill ſubſiſting, wherein this rule of Vitruvius is exemplified, *viz.* the temple of Apollo near Miletus, and the Ionic temple on the Iliſſus at Athens; in both of which examples the cathetal line of the capital recedes from the abacus as much as Vitruvius preſcribes.

It may be worth obſervation, that the baſes as well as capitals of the columns of the ſaid temple at Miletus agree very nearly, in form and proportion, with the deſcription that Vitruvius gives of the Ionic baſe and capital; from whence it may be inferred, with ſome probability, that they were wholly formed on the rules he has tranſmitted to us; and that the volute may be conſidered as the true Vitruvian volute, the conſtruction of which ſo many ingenious perſons have employed themſelves to diſcover.—A repreſentation of it may be ſeen in the Ionian Antiquities.

BOOK III. Ch. III. Note (16). In confirmation of the reaſoning of this note, as well as to ſhew that the text is in this place probably authentic, the antient Greek temple on the Iliſſus at Athens may be produced as an example; for, in this building, the abacus of the capital is in length and breadth equal to a diameter, and about one ninth, of the bottom of the column; and the height of the ſaid column is fourteen feet eight inches, Engliſh meaſure. So that it becomes highly probable that Vitruvius intended the abacus to be of this proportion, in columns of the height of fifteen feet and under, as argued in the note; and the former meaſure mentioned by him, *viz.* one diameter and $\frac{1}{18}$, to relate to all columns above that height. As it appears from ſeveral circumſtances that Vitruvius had ſtudied and drawn many of his rules from ancient Greek buildings remaining in his time; ſo in this inſtance it is not improbable that he may have had in remembrance the aforeſaid temple, the delineation of which may be ſeen in the firſt volume of Mr. Stuart's Athenian Antiquities.

BOOK III. Ch. III. Note (17). To the arguments on the ſcamilli impares I can now add the ſupport of ſeveral antient examples. When I wrote that note, I had not met with any inſtance in which the ſmall fillets that I ſuppoſed to be the ſcamilli were uſed in the baſes of columns, except in the Sybil's Temple at Tivoli. Since then, I have ſeen ſeveral repreſentations of antient buildings in which they were applied as in the Temple of Bacchus at Teos, and Temple of Minerva at Priene, repreſented in the Ionian Antiquities, both of

which have ſuch fillets in the baſes of their columns: they are not under the baſes; becauſe the Greeks made the joints of the ſtones in different parts, and frequently made the baſe, or part of the baſe, of one piece with the ſtep on which it ſtood (as in the firſt of theſe examples); but they are in both caſes at that part of the baſe where the joints have been made, ſo that they are equally well ſituated to anſwer the purpoſe of ſcamilli as if they were under the whole baſe. In the Parthenon, and Temple of Theſeus, at Athens, and in ſome other Doric temples, they are uſed at that part where the capital is ſet on the ſhaft of the column; for the ſmall fiſſure there obſerved appears to be for that purpoſe only. Another example is, the Temple of Pola in Iſtria, in which theſe fillets or ſcamilli are found both under the baſes and over the capitals of the columns, exactly as Vitruvius mentions. Theſe fillets have not been ſeen by Palladio, Le Roi, and others, who had meaſured this temple: and it is owing to Mr. Stuart, and Revett's accurate delineations (not yet publiſhed), that I am enabled to produce this example. The ſcamilli are alſo uſed in the antient arch yet ſtanding at the ſame place. Over the capitals they are to be ſeen in many antient remains; as, in the Ionic temple on the Iliſſus at Athens; the Portico of Octavia, called by Deſgodetz the Portico of Severus, at Rome; the Temple of Antoninus and Fauſtina; the Forum of Nerva; the Arch of Titus; the Thermæ of Diocleſian; and in the remains of the Temple of Jupiter Tonans. In this latter there appears a double ſcamillus, one above the other; the upper one is of white marble, and is let into a cavity made in the lower one. So that it appears very probable they were uſed for the purpoſes I have conjectured, that of raiſing the epiſtylium to a level, where the columns have varied a little in their height; as well as to prevent rupturing the edges of the capitals, &c.

BOOK IV. Ch. II. Note (1). In this note I argued the *tranſtra* to be the principal rafters of a roof; but I have ſince met with a paſſage at book x. ch. xxi. where the term is applied to the horizontal timbers of a floor—*ita ſupra tranſtrorum planitiem:* however, at book ii. ch. i. it is evidently uſed for the rafters, or the inclined timbers riſing from the four corners of a building, and meeting in a point in the middle of the roof—*item tecta recidentes ad extremos angulos tranſtra, gradatim contrahentes.* Hence it appears that Vitruvius uſes the term in both ſenſes; and perhaps it may be applicable to all timbers laid tranſverſely over a void, whether horizontally or inclined. The rowers benches, that croſſed the ſhip from one ſide to the other, were diſtinguiſhed by the ſame term.

BOOK IV. Ch. III. Perrault has altered the text, on a ſuppoſition that it is erroneous in that place of this chapter, where Vitruvius preſcribes the breadth of the Doric capital to be two modules and a ſixth part; a proportion that he, following Barbaro, thinks too ſmall to be endured: it has however the authority of a very antient example now ſubſiſting, *viz.* the Doric Portico at Athens; in which the breadth of the *abacus* of the capital is rather leſs than two modules and a ſixth, according to the meaſures given thereof in Mr. Stuart's Antiquities of Athens, vol. i.

BOOK IV. Ch. VI. The antient door of the Pantheon at Rome, according to Deſgodetz, appears to have been framed in the manner Vitruvius deſcribes, and exemplifies his text very exactly. For of the two middlemoſt impages, or horizontal rails, of this door, the upper one was at three fifths of the height, and the other at the middle of that height, agreeing therein with the directions of Vitruvius. I have therefore now altered *Fig. XXXI.* accordingly.

There are ſeveral examples of antient doors to be ſeen on marble ſarcophagi, which are framed in pannels. One is repreſented in Pirancſi's Antiquities of Rome, vol. iii. pl. 27: another is in the collection at Wilton, on a ſarcophagus which ſtands in the great hall. In both theſe examples one leaf of the door is repreſented opening outward, in which manner it is ſaid the doors of the antient Greeks uſually opened. See Plutarch in the Life of Poplicola.

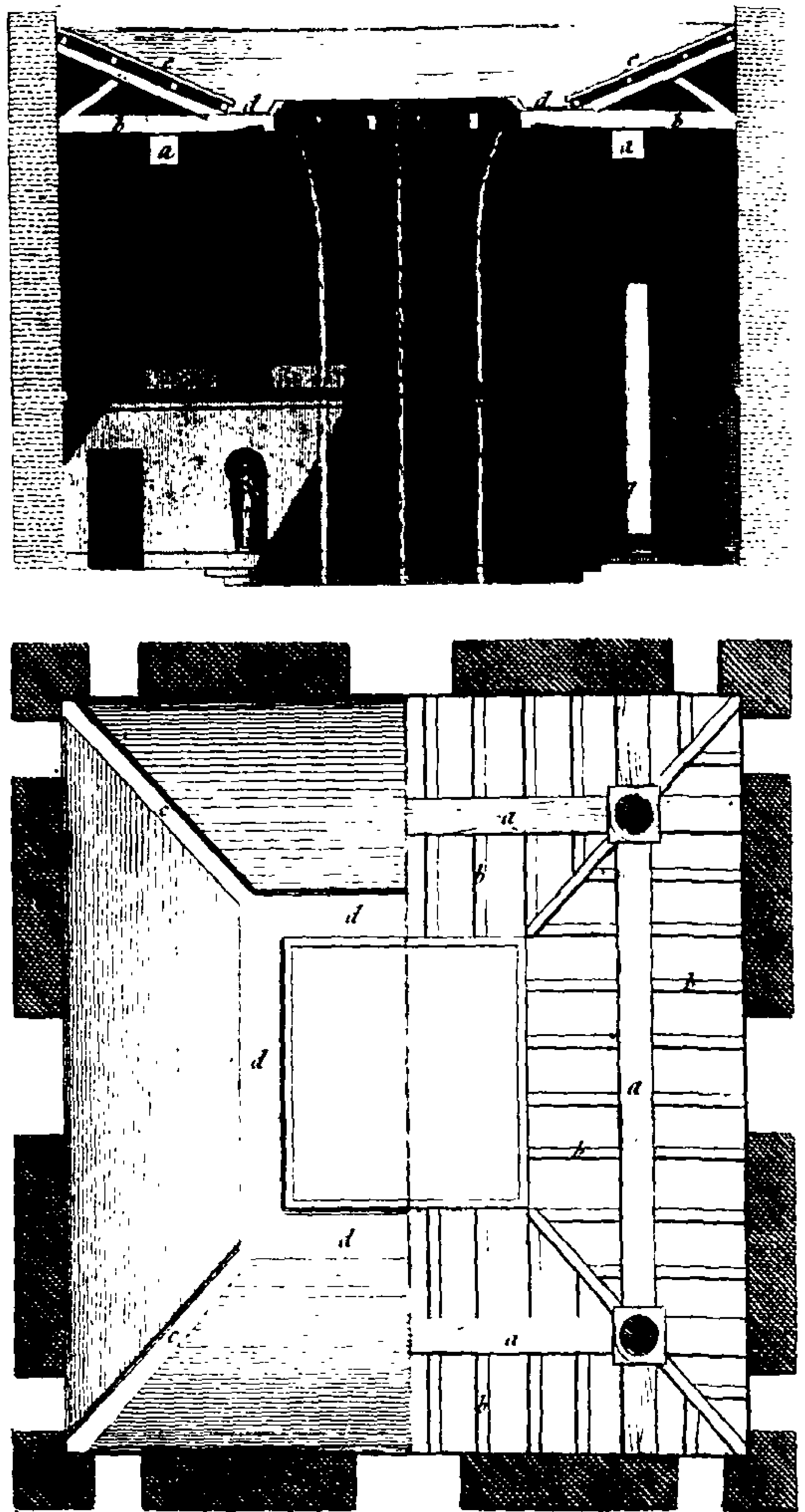


Fig. LIII. Fig. LIV.

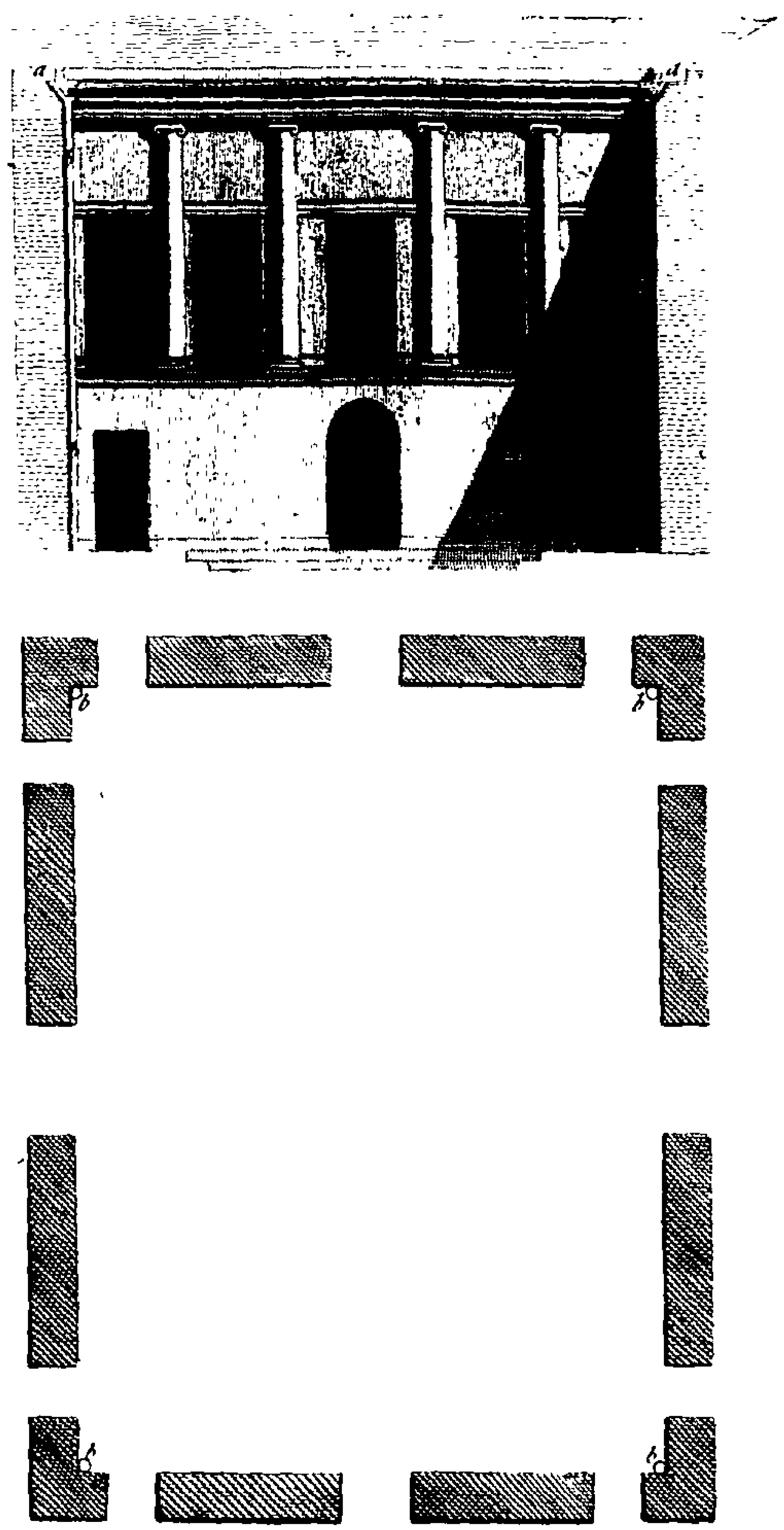


Fig. LV.

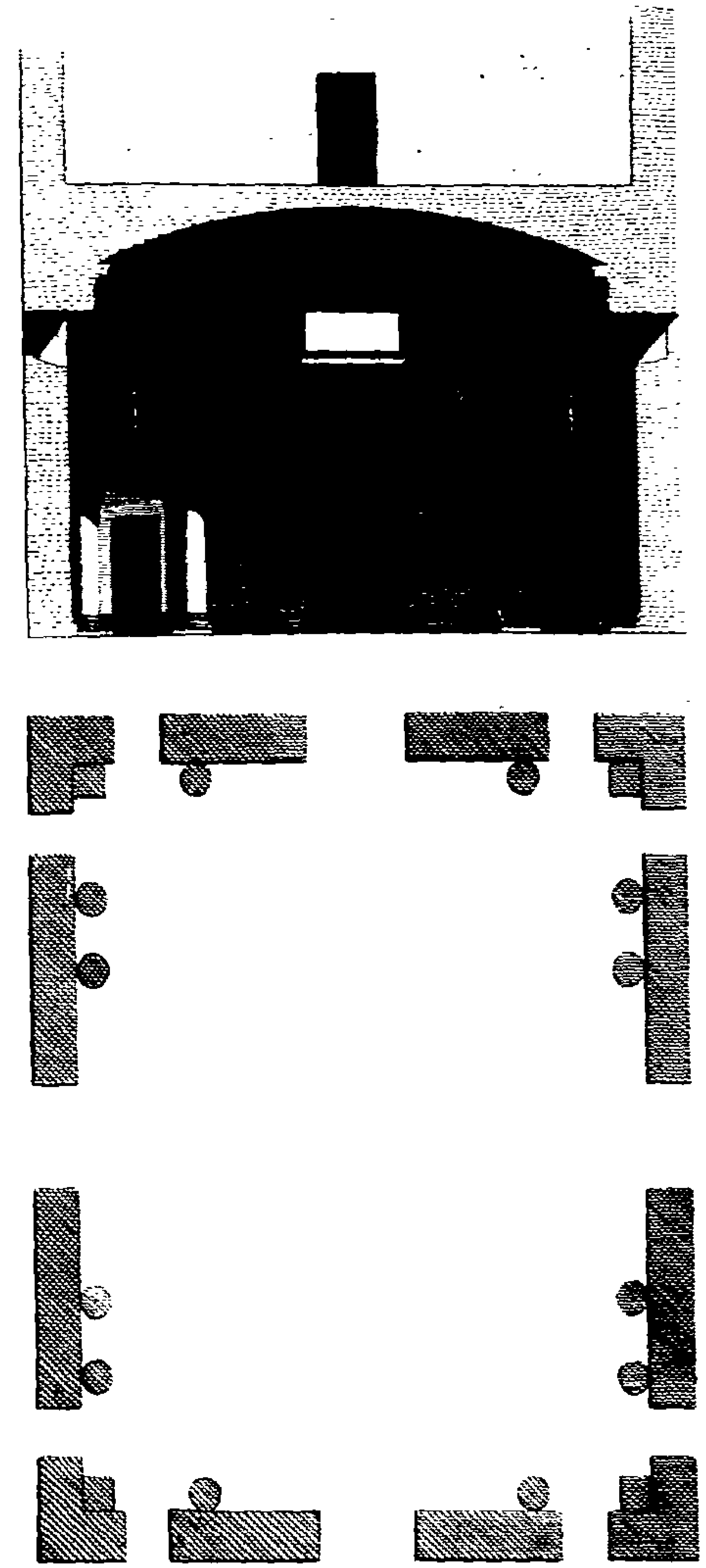


Fig. LVI.

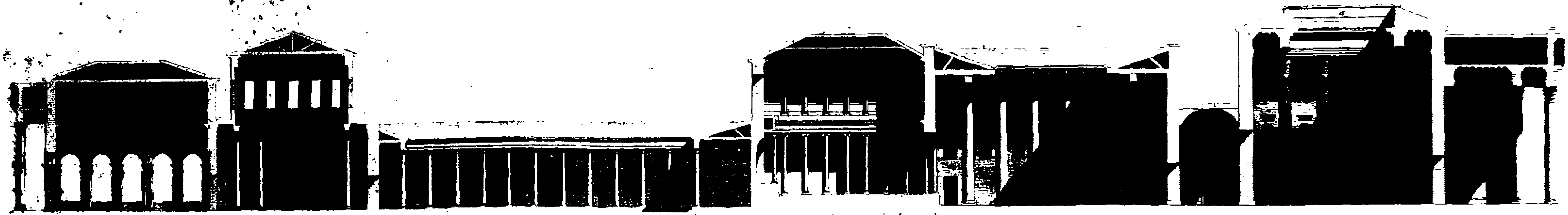


Fig. LVIII. Section through the middle of the Building.

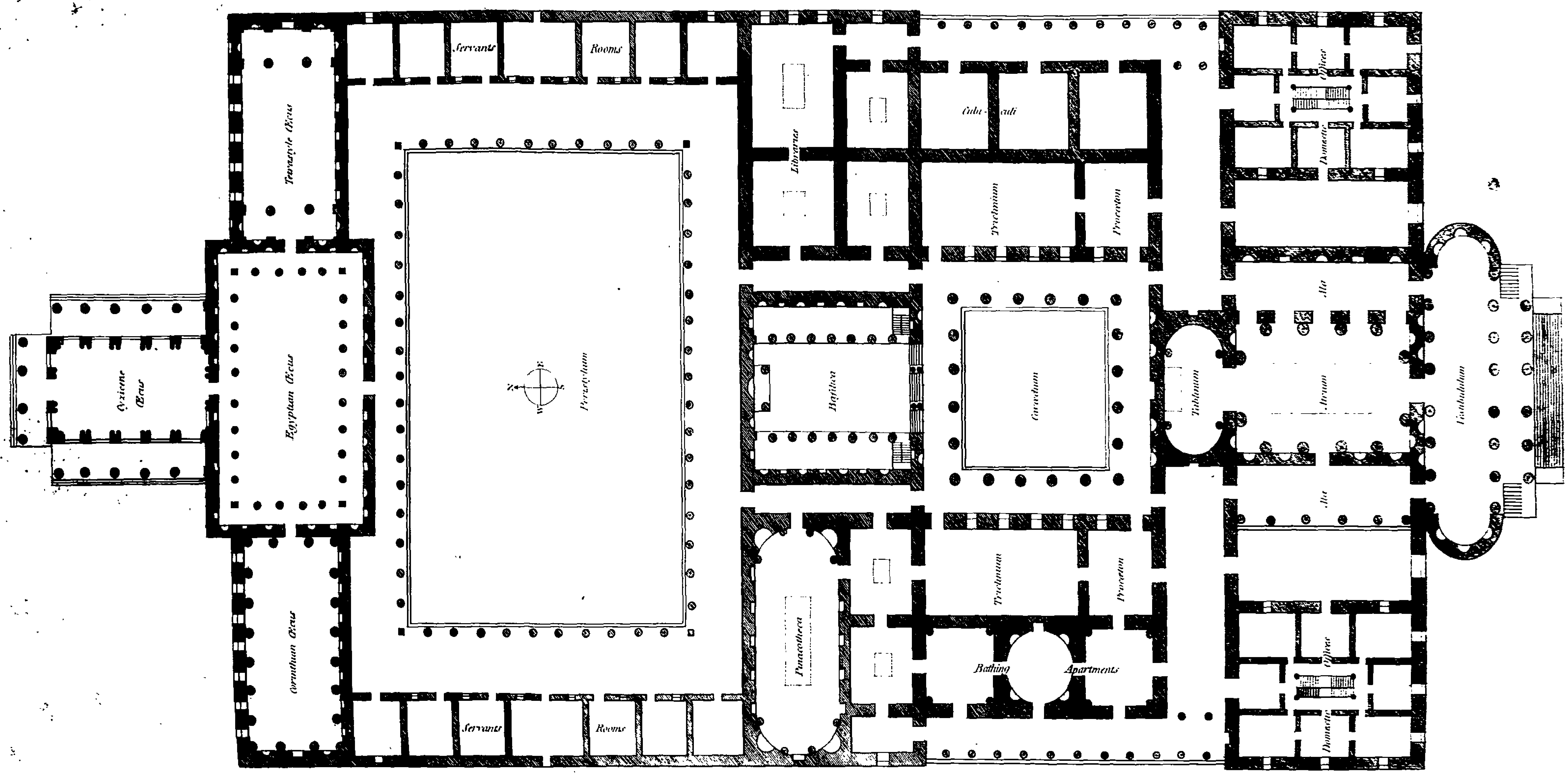
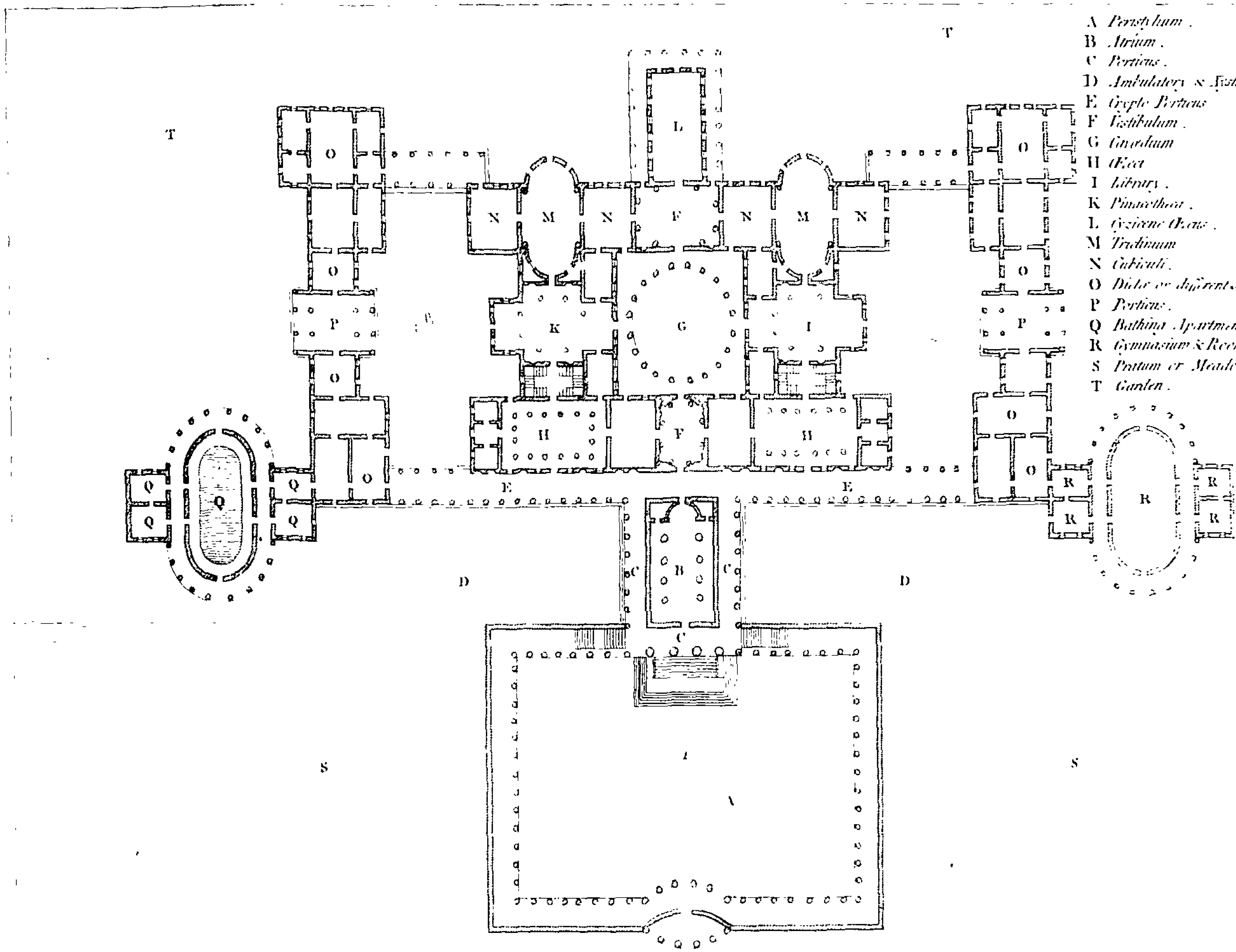
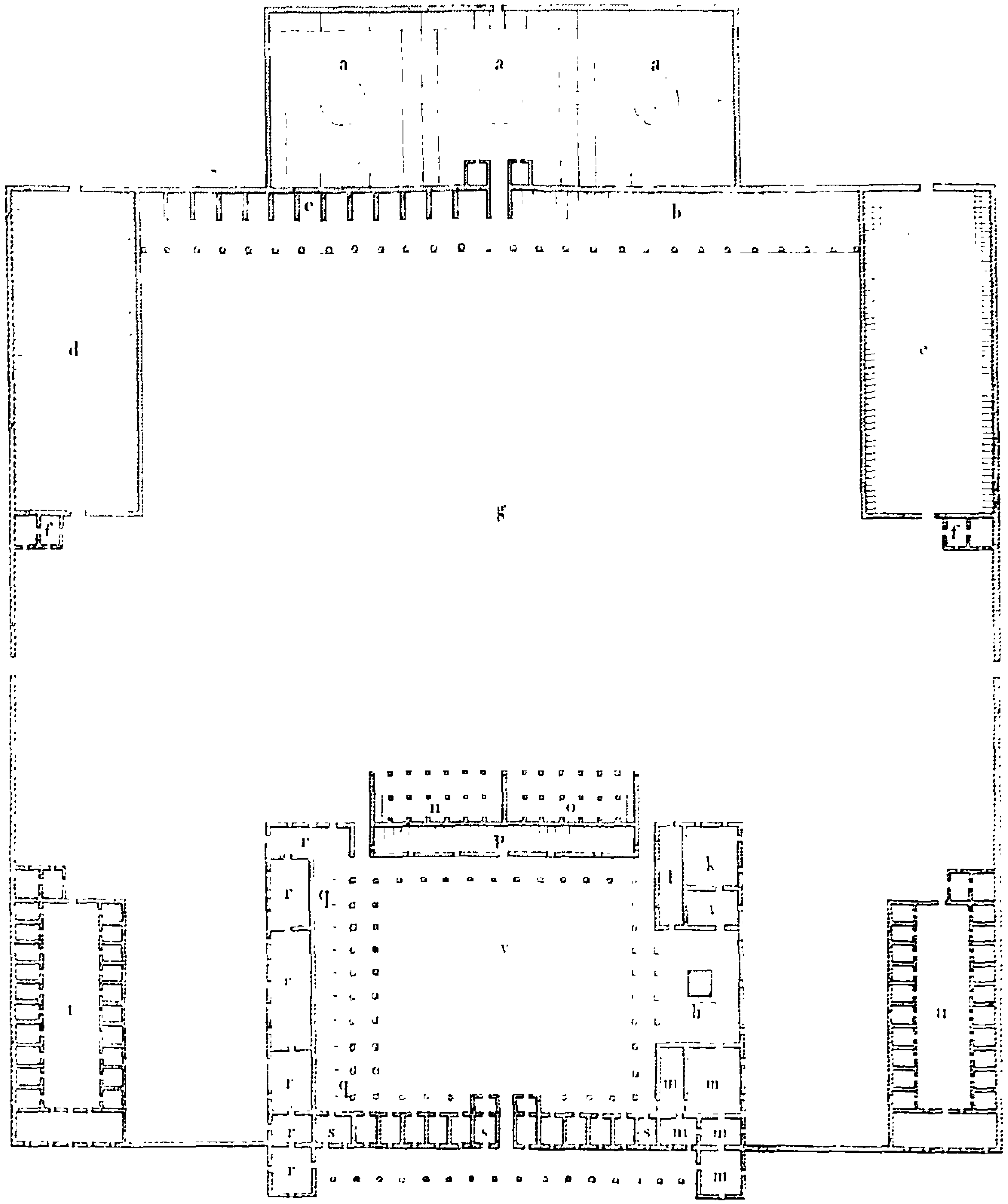


Fig. LVII



A Peristylium.
B Atrium.
C Porticus.
D Ambulatory & Xystus
E Crypto Porticus
F Vestibulum.
G Cavædium
H Œci
I Library.
K Pinacotheca.
L Cyzicene Œcus.
M Triclinium
N Cubiculi.
O Dietæ or different Sets of Apartments.
P Porticus.
Q Bathing Apartments
R Gymnasium & Rooms appertaining
S Pratum or Meadow
T Garden.

Villa Pseudo Urbana, Fig LIX.



a *Aviarium*
b *Hog Styes & Dog Kennels.*
c *Houses for Carts & implements*
d *Ovilia.*
e *Caprilia.*
f *The Keepers house*
g *Piscina.*
h *The Kitchen*
i *The Torcularia.*
k *The Vinaria.*
l *The Olearia*
m *Farm Offices.*
n *Granary.*
o *Oporotheca.*
p *Equilia*
q *Bubilia*
r *Apartments for the Baths*
s *Domestic Rooms.*
t *Apartments for the Male Slaves*
u *Ditto of the Female Slaves.*
v *The Chors Culinae.*

Villa — Rustica Fig. LX.

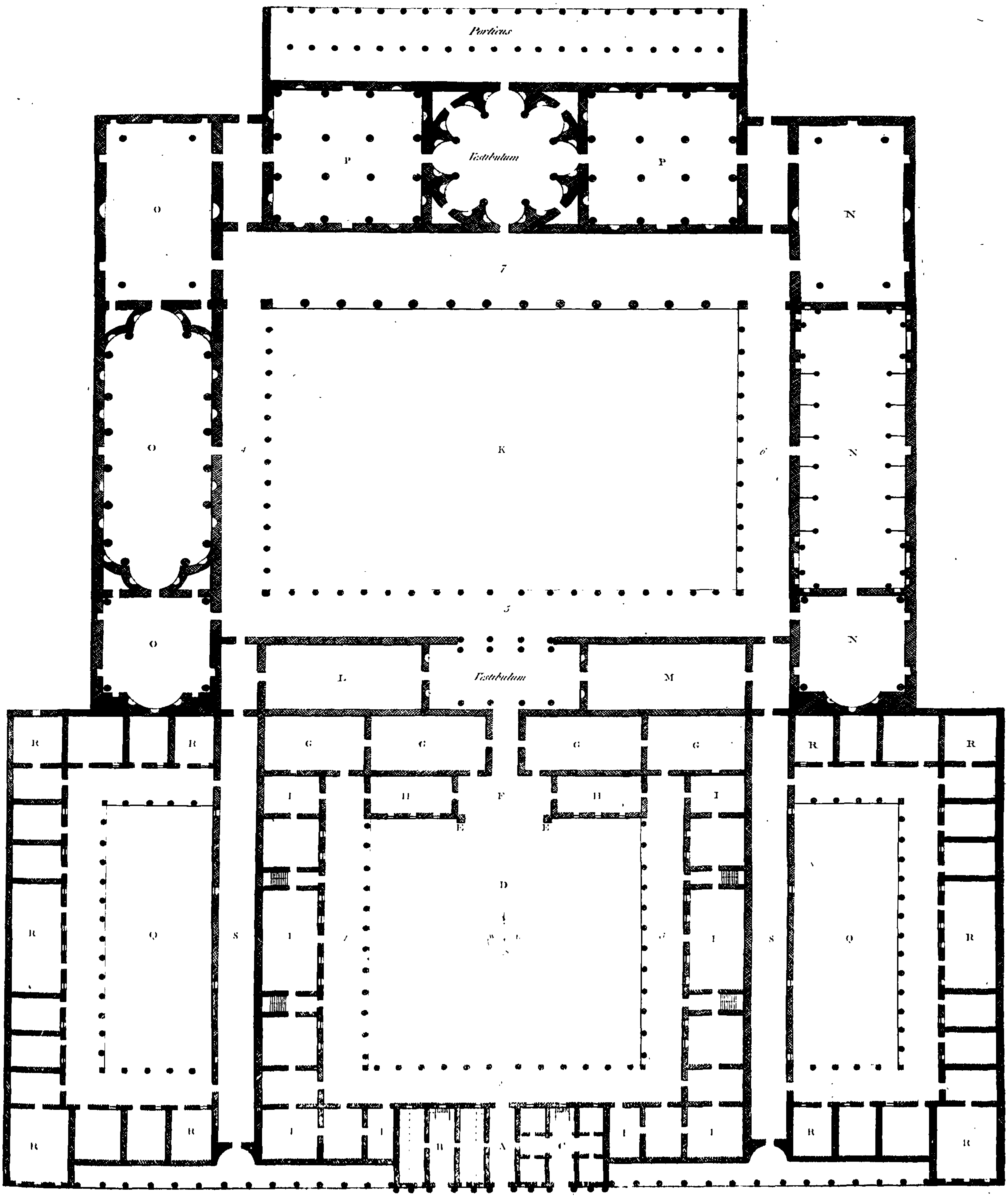

Porticus
Vestibulum
P
P
O
N
7
O
K
4
6
N
5
O
N
L
Vestibulum
M
G
G
G
G
R
R
R
R
I
H
F
H
I
E
E
D
R
Q
S
I
I
S
Q
R
I
I
B
A
C
I
I
R
R
R
R

Fig. LXI.

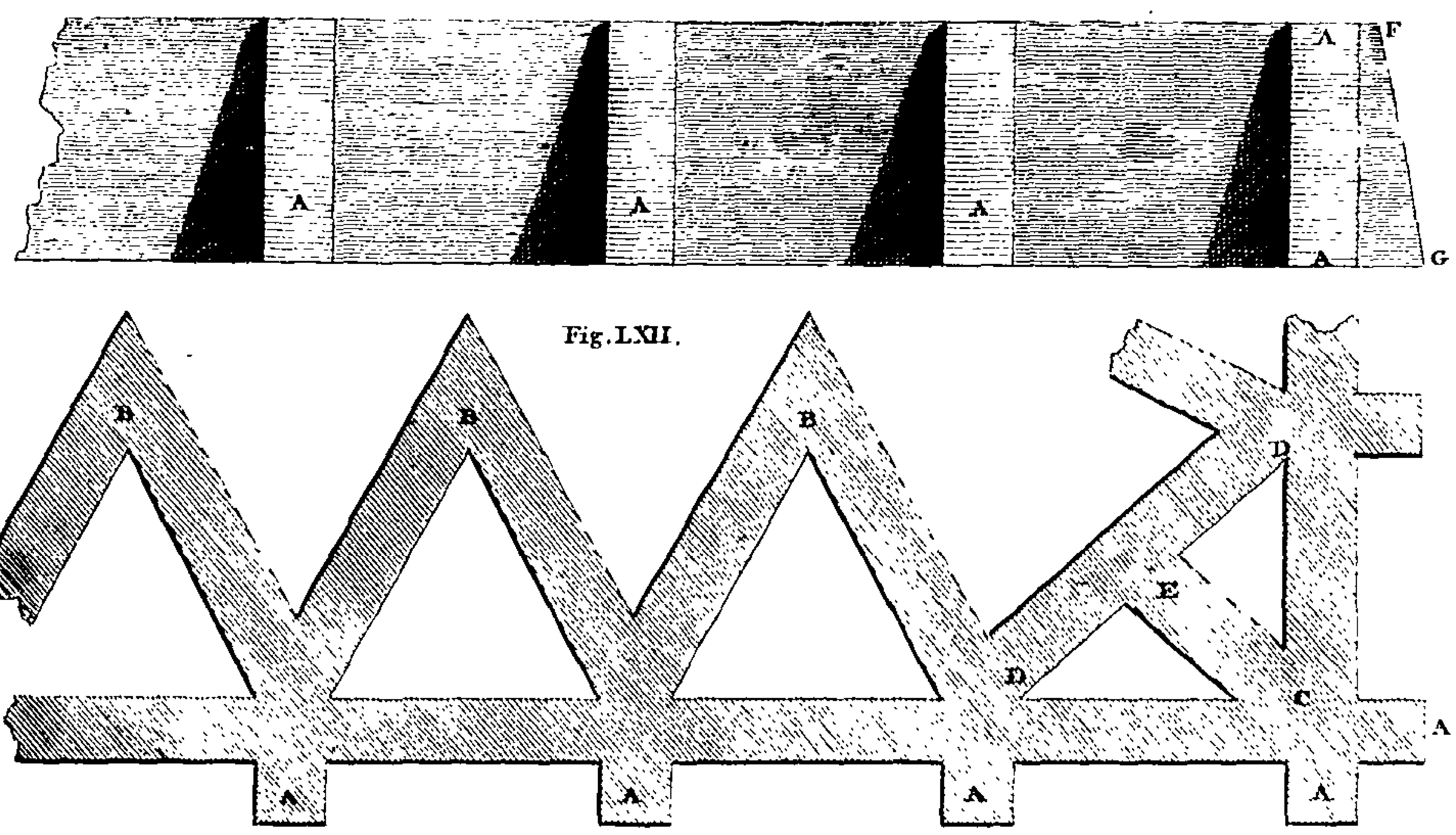


Fig. LXII.

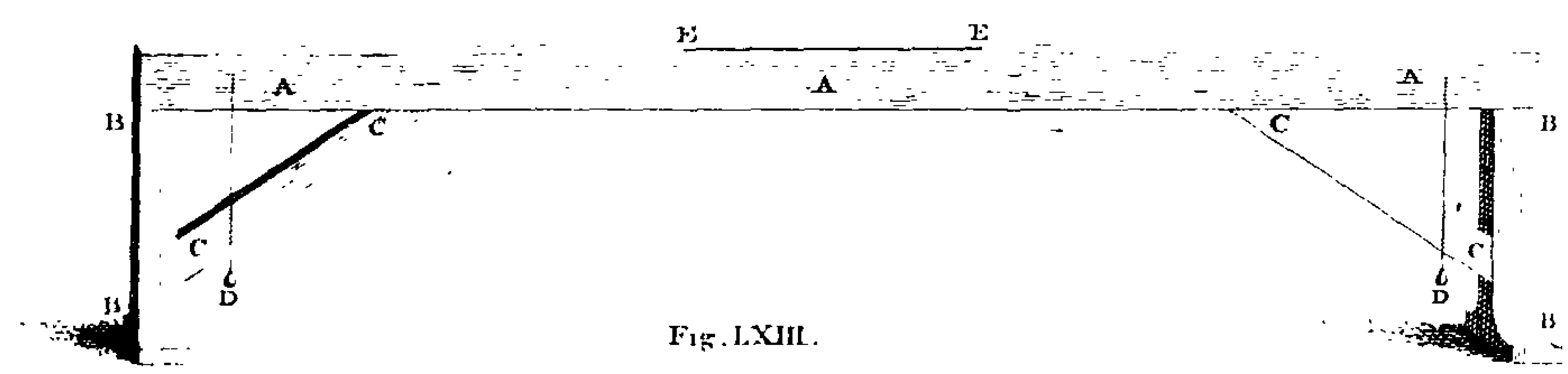


Fig. LXIII.

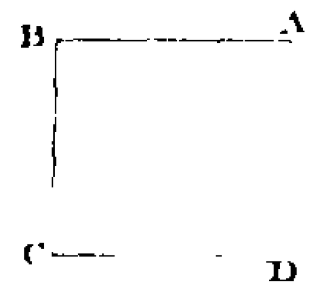


Fig. LXIV.

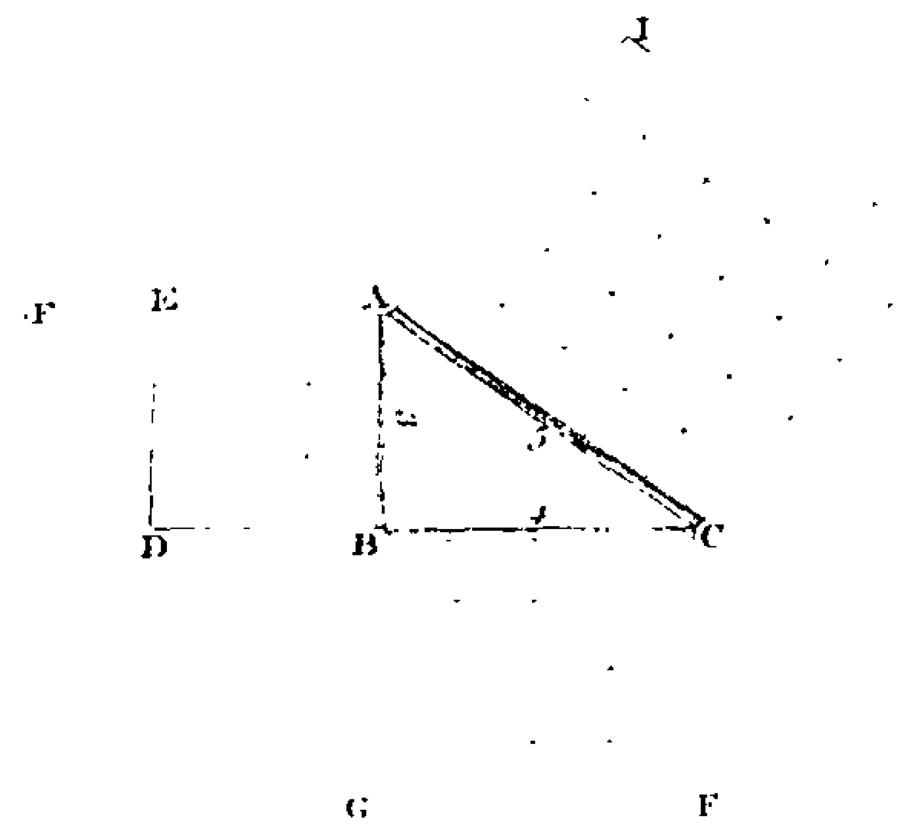


Fig. LXV.

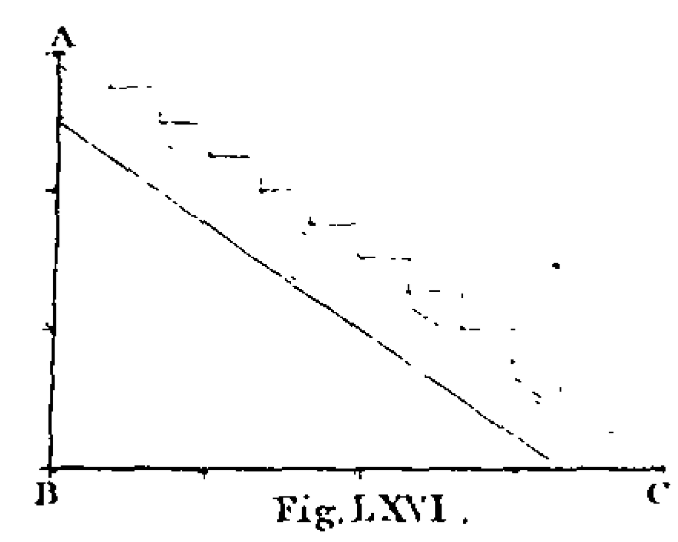


Fig. LXVI.

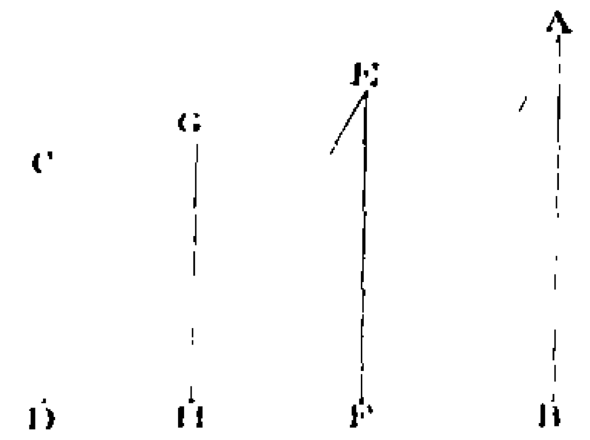


Fig. LXVII.

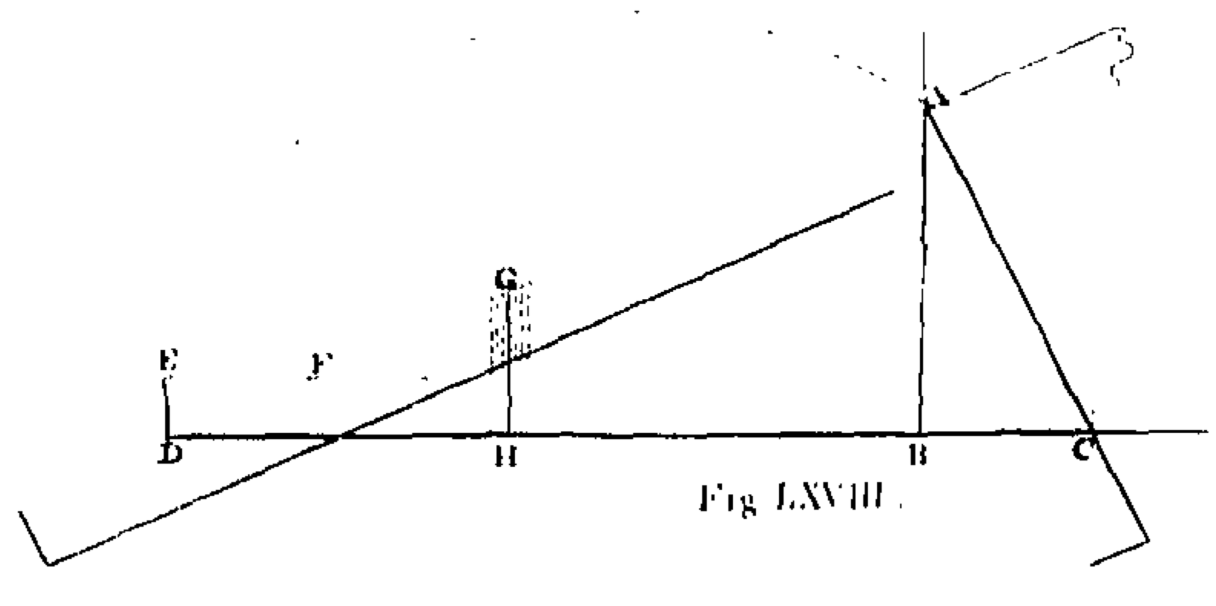


Fig. LXVIII.

Fig. LXIX.

Fig. LXX.

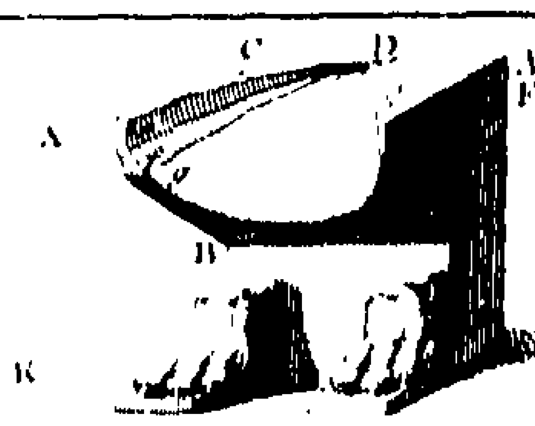
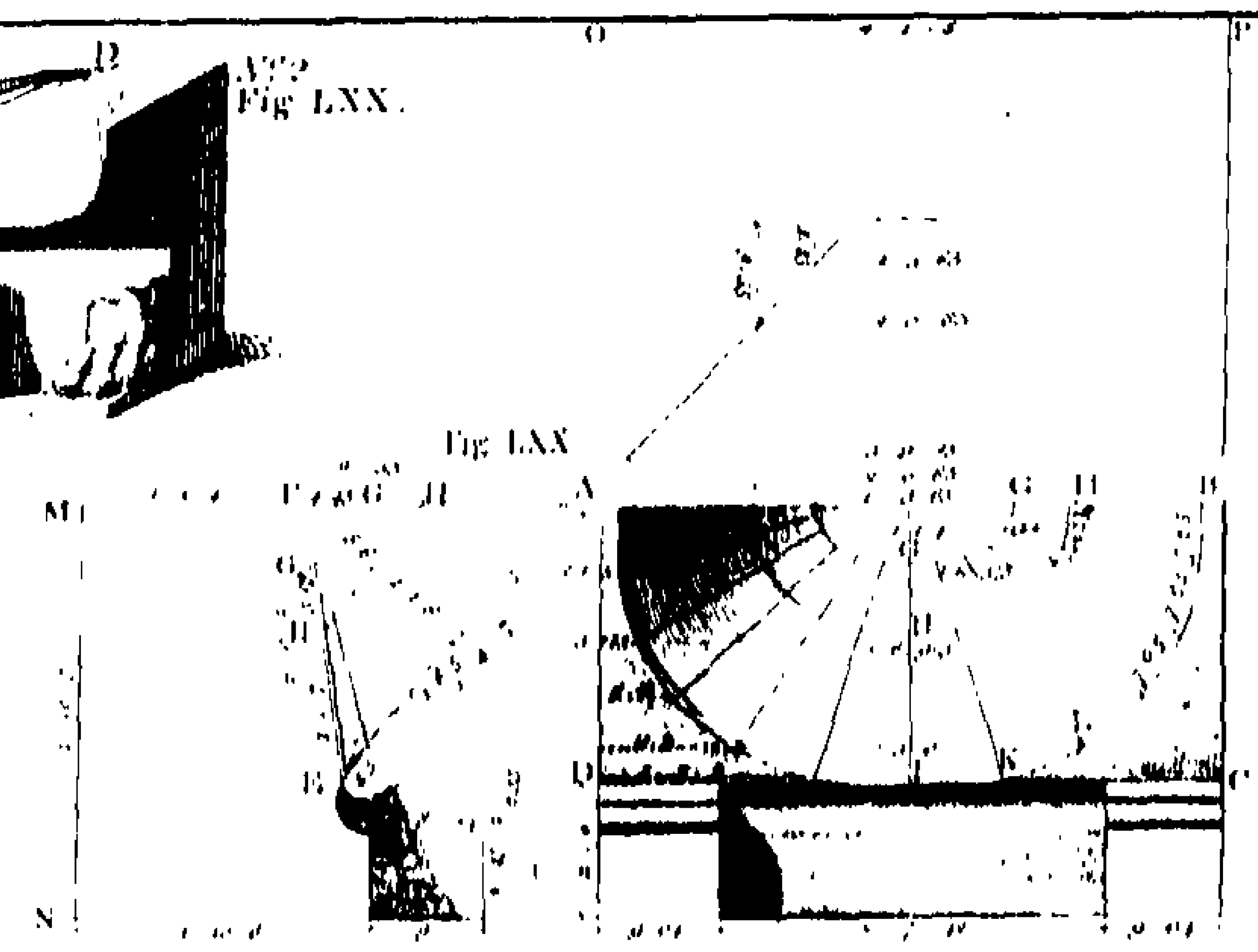


Fig. LXX.



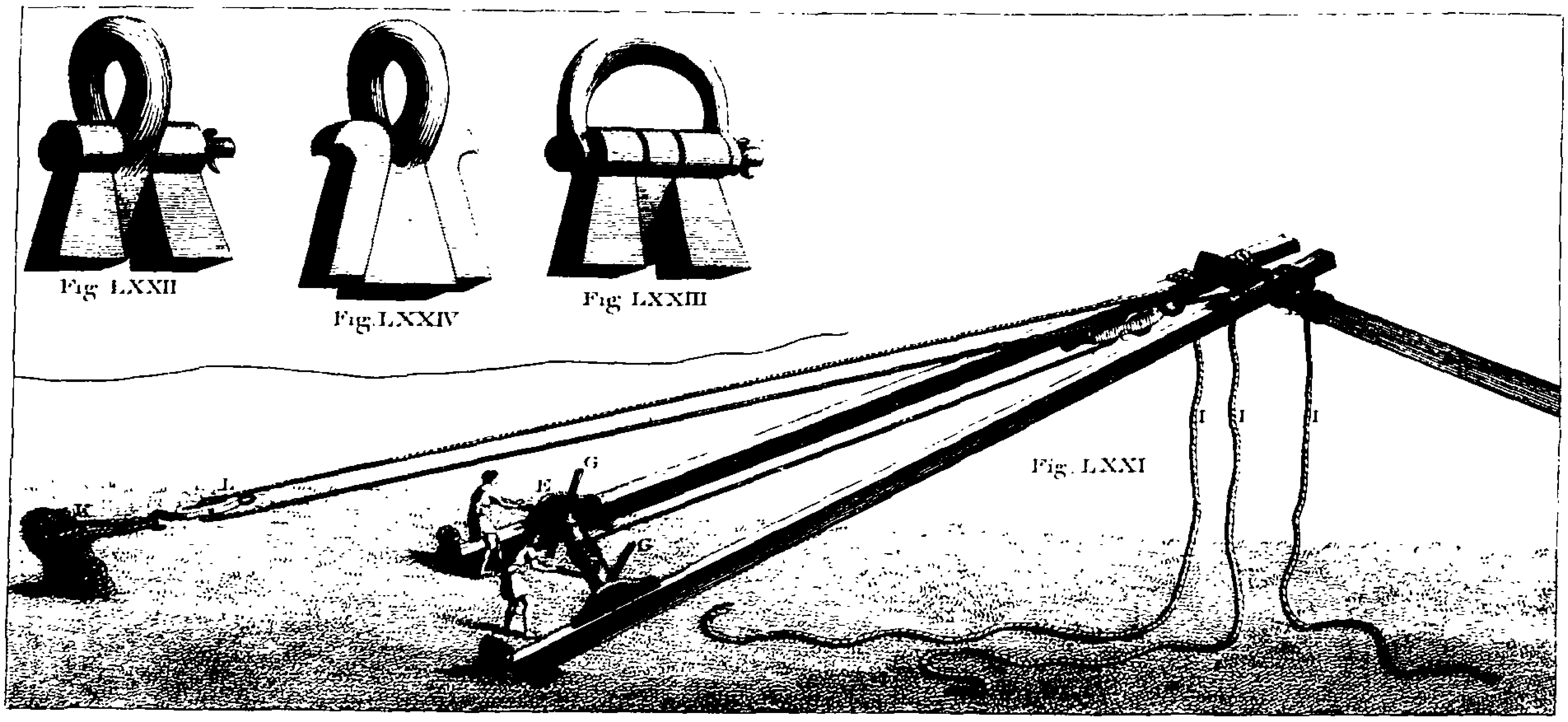
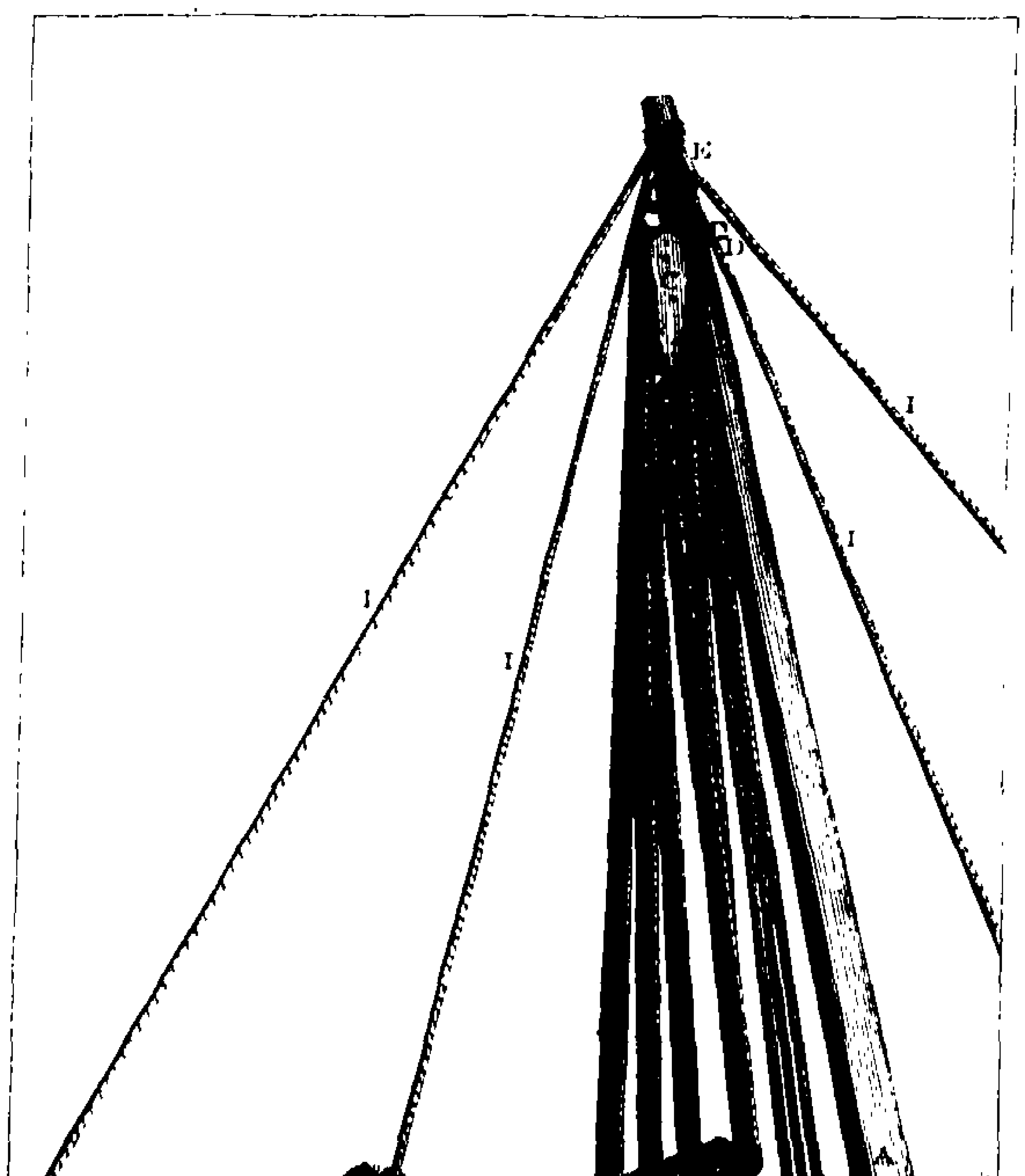


Fig. LXXII
Fig. LXXIV
Fig. LXXIII
Fig. LXXI



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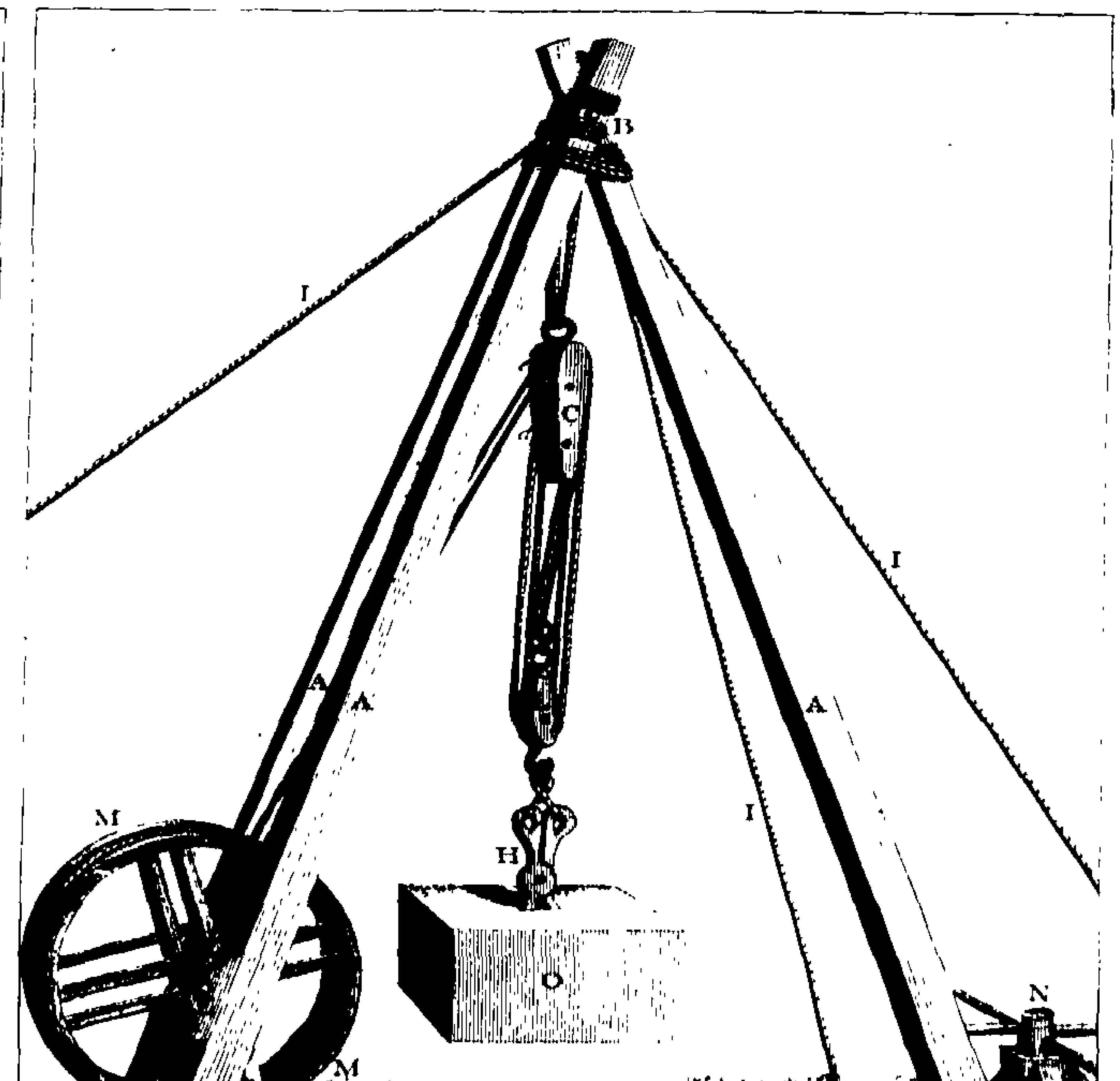


Fig. LXXV

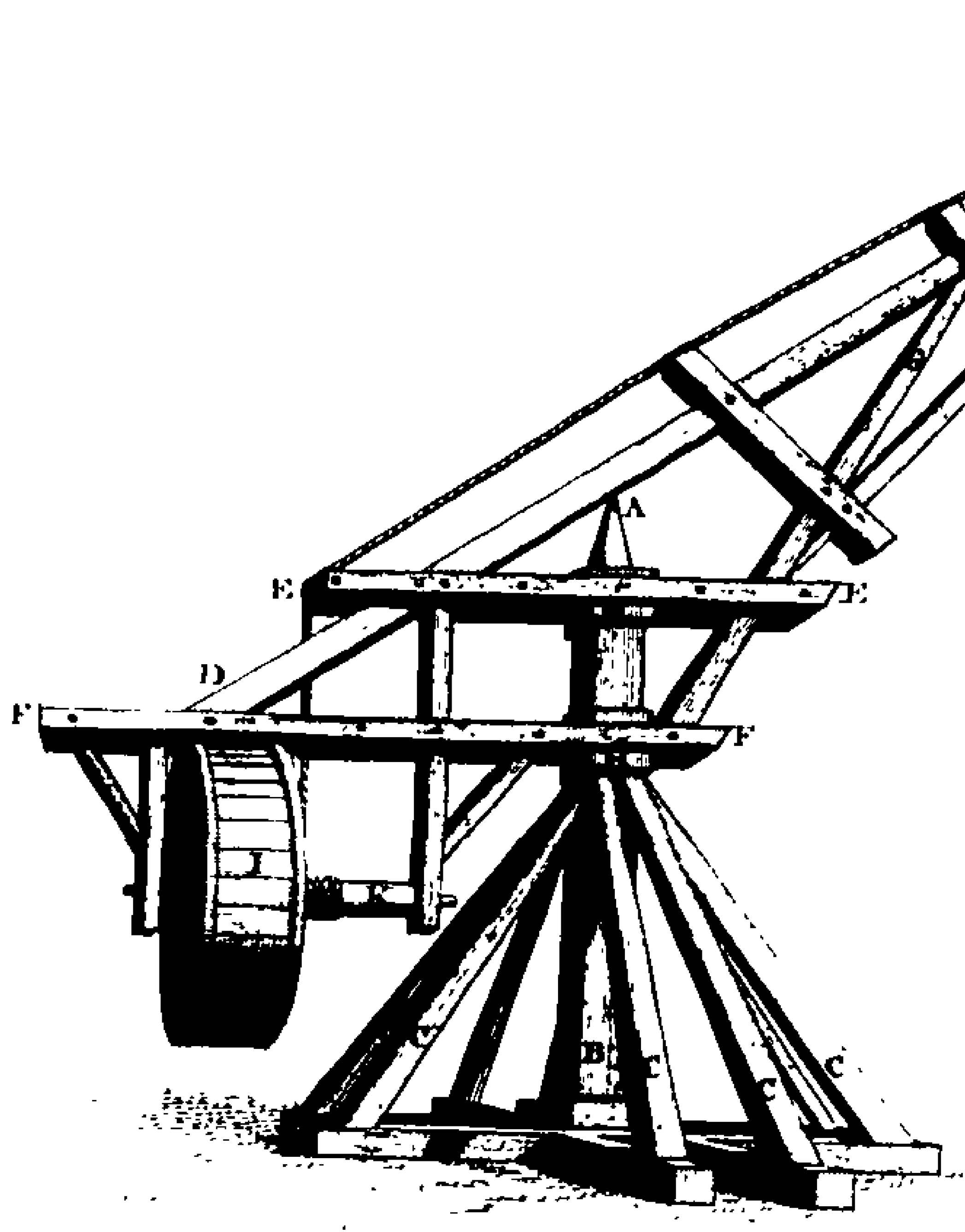


Fig. LXXVII.

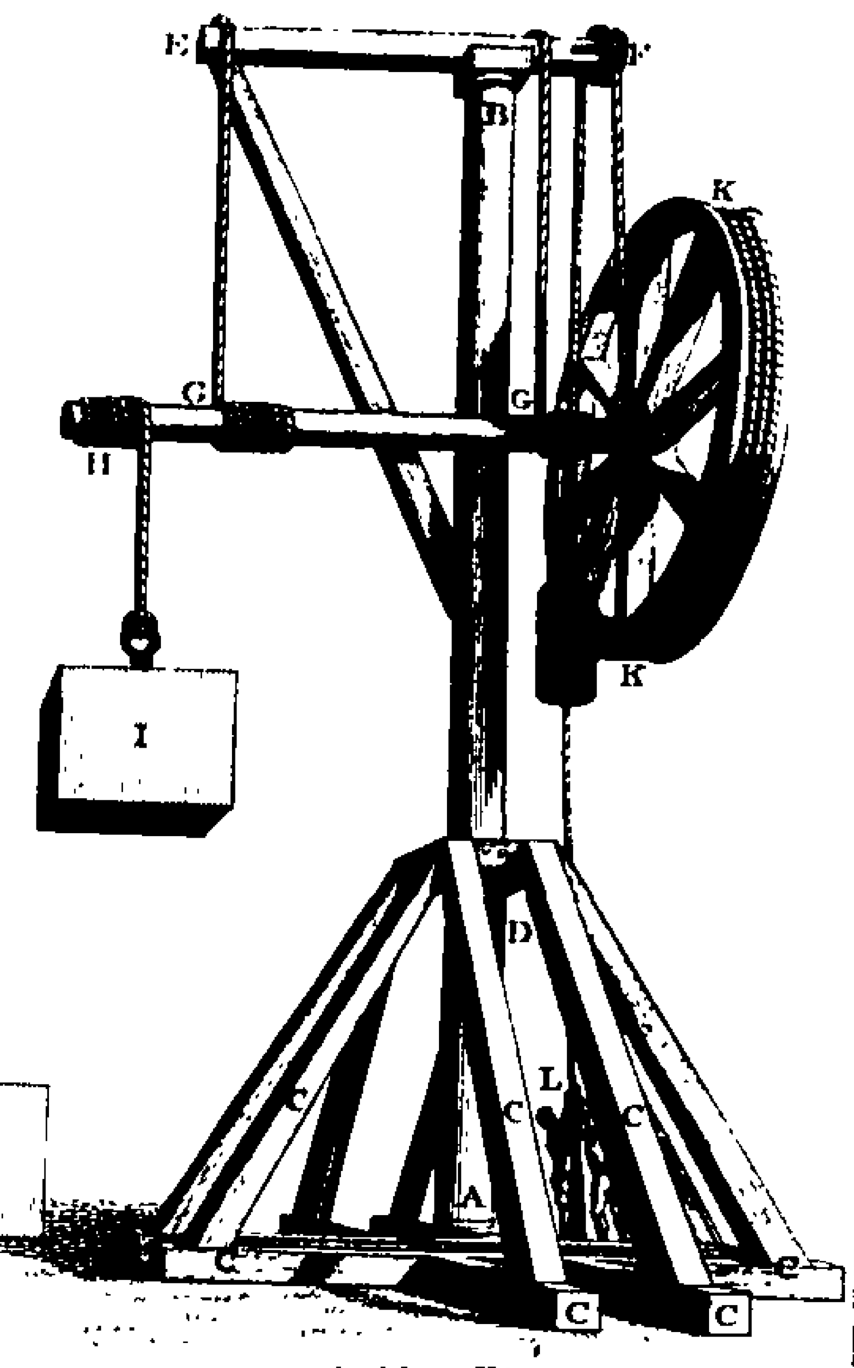
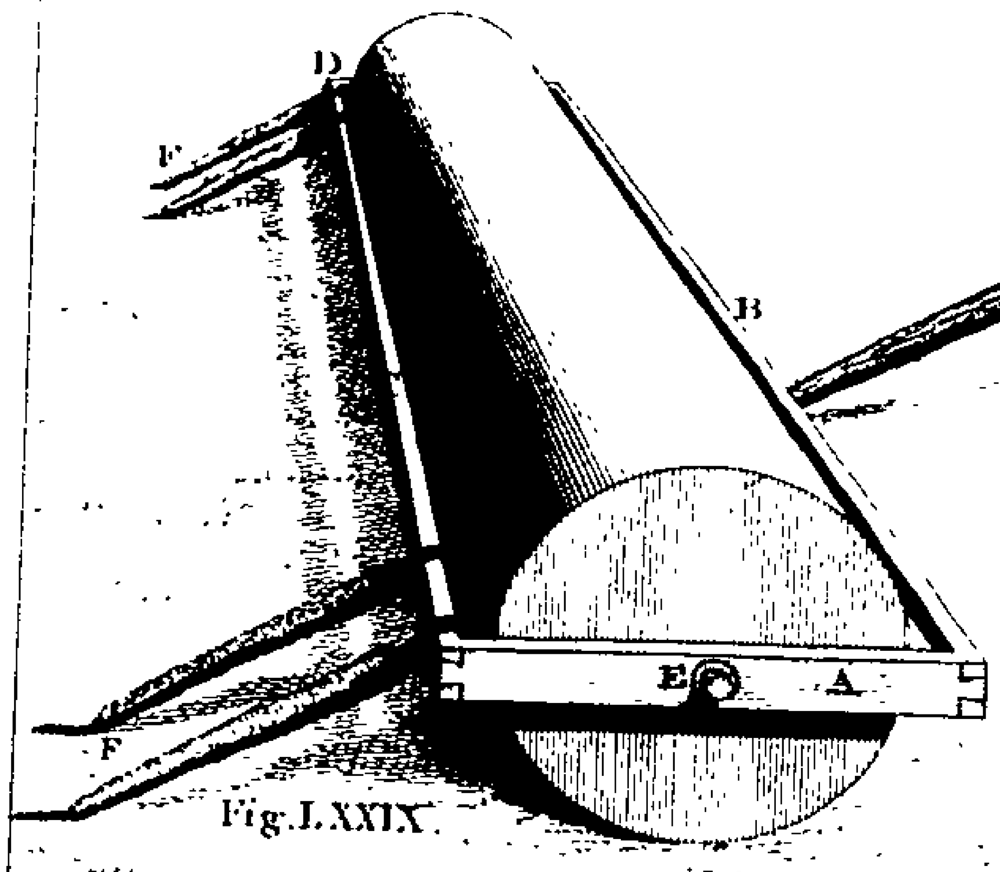


Fig. LXXVIII.



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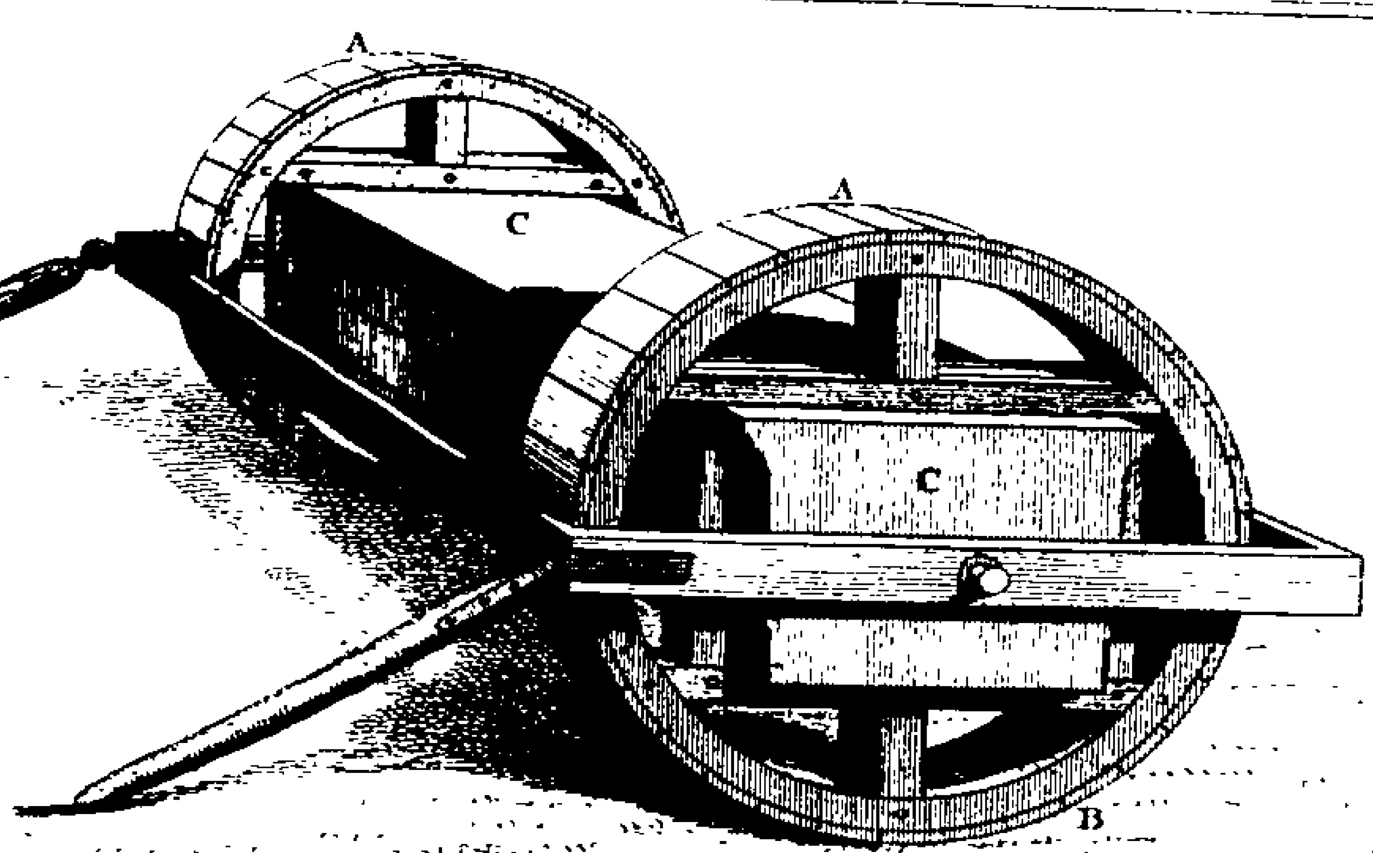


Fig. LXXX.

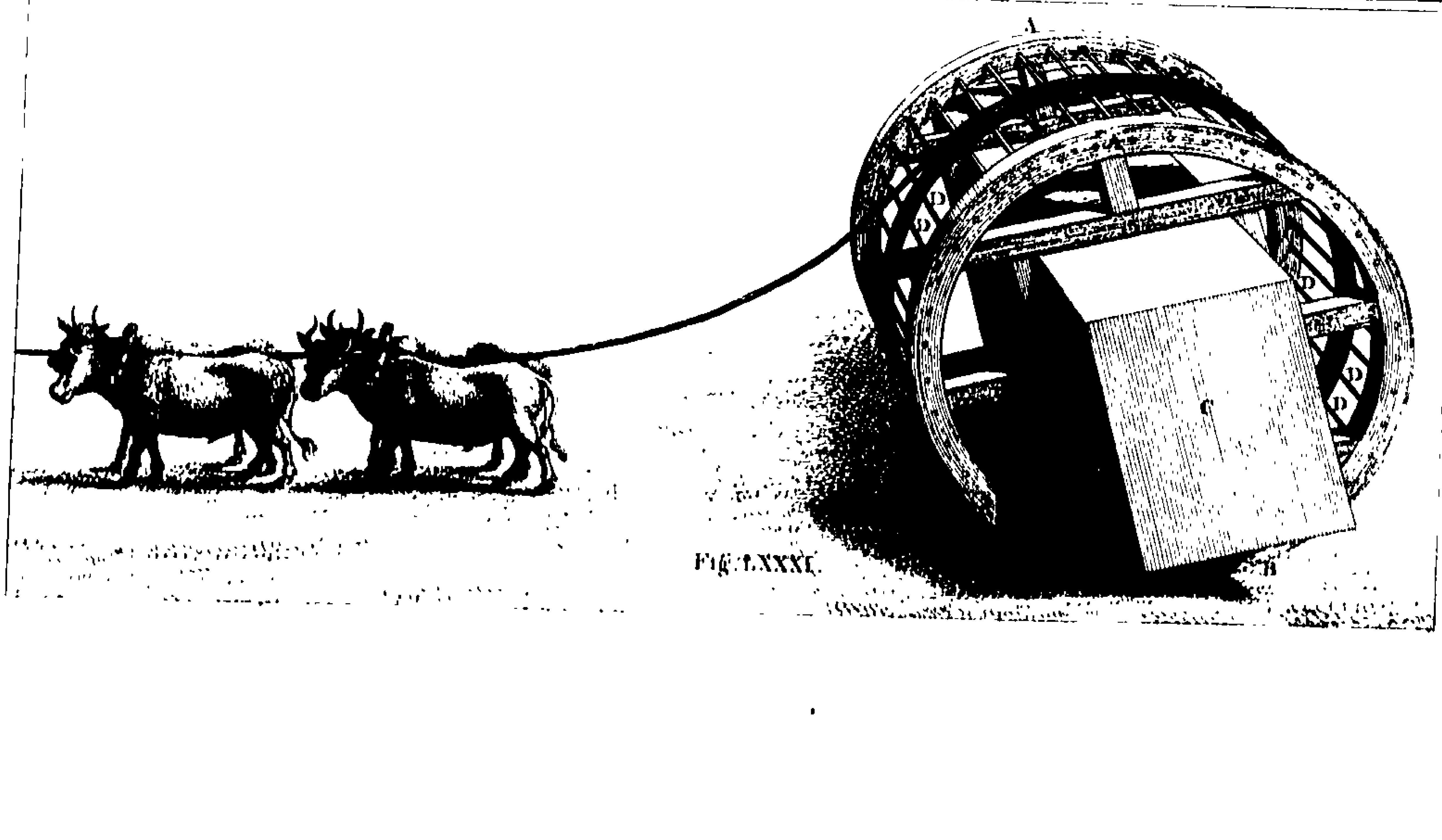


Fig. LXXXI.

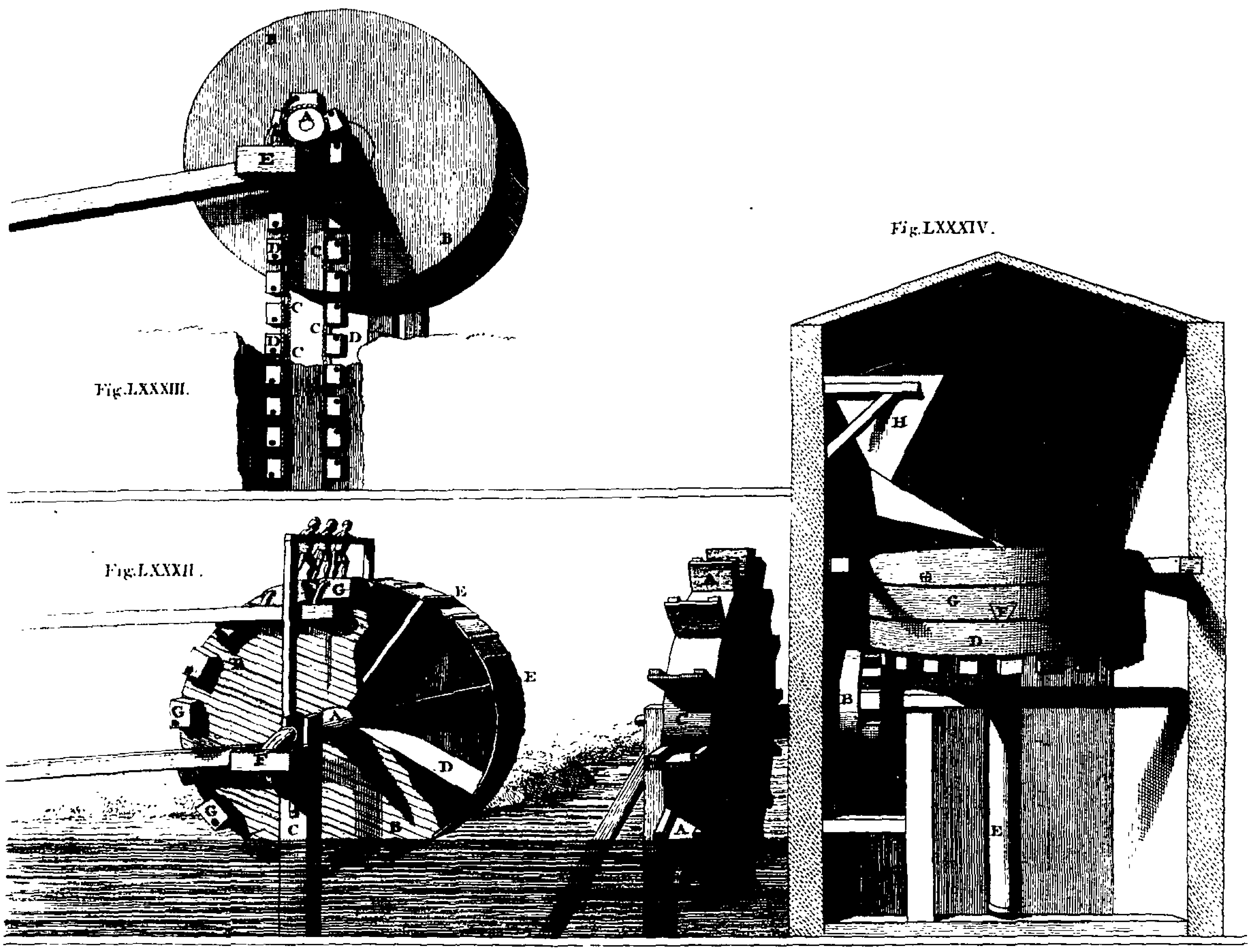


Fig. LXXXIII.

Fig. LXXXII.

Fig. LXXXIV.

Fig. LXXXV.

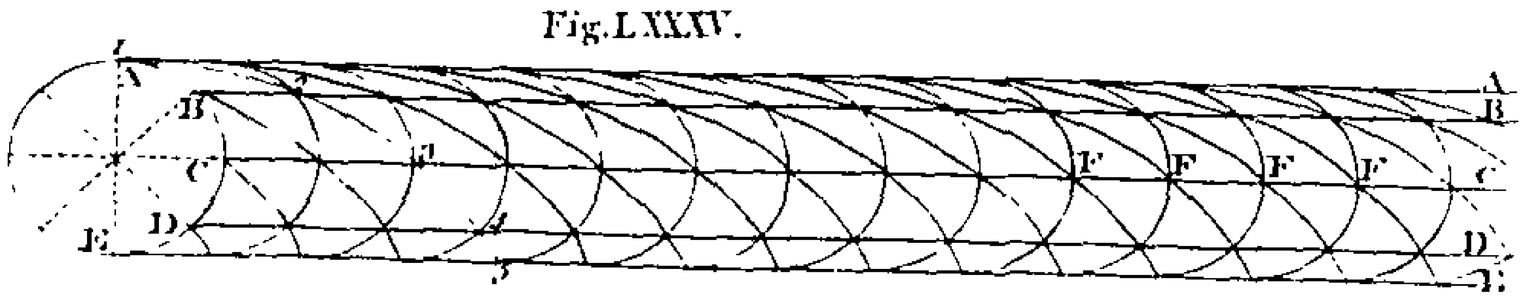
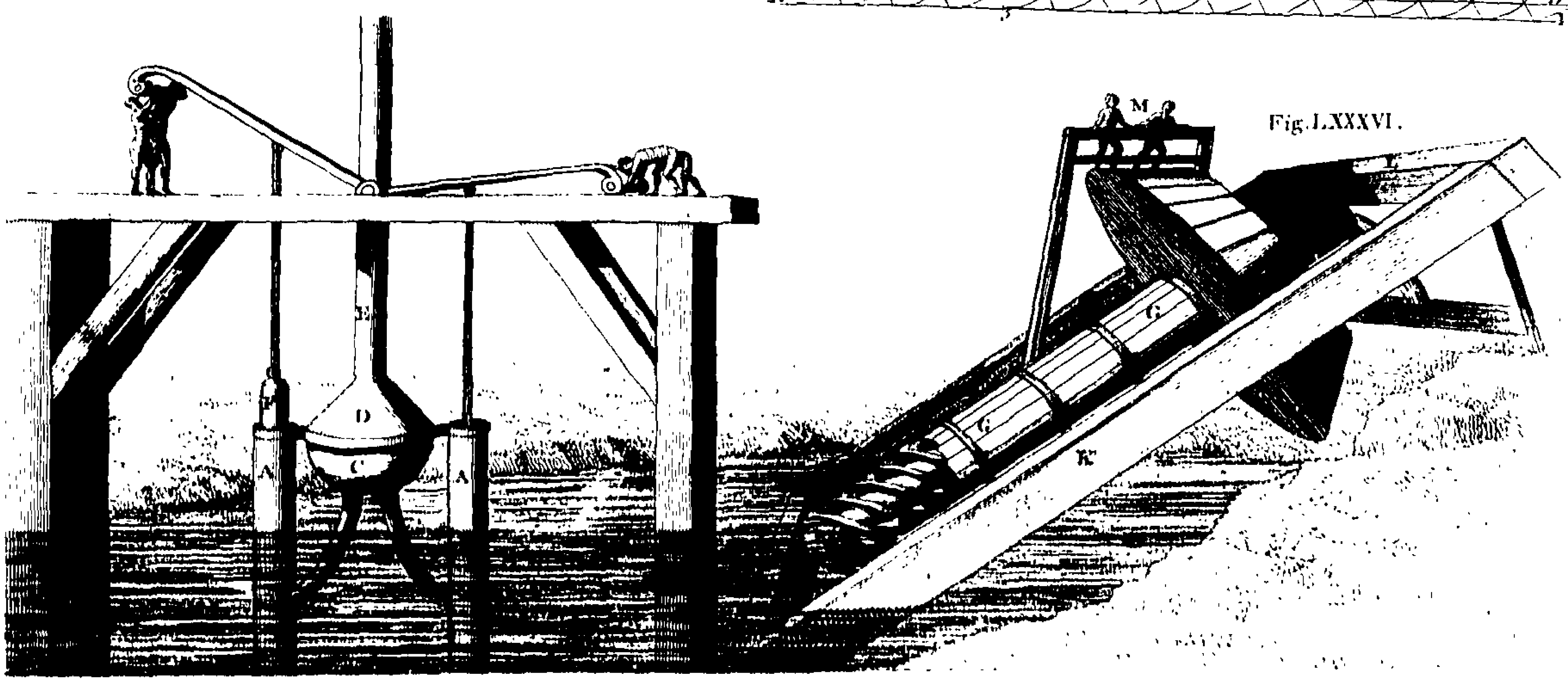
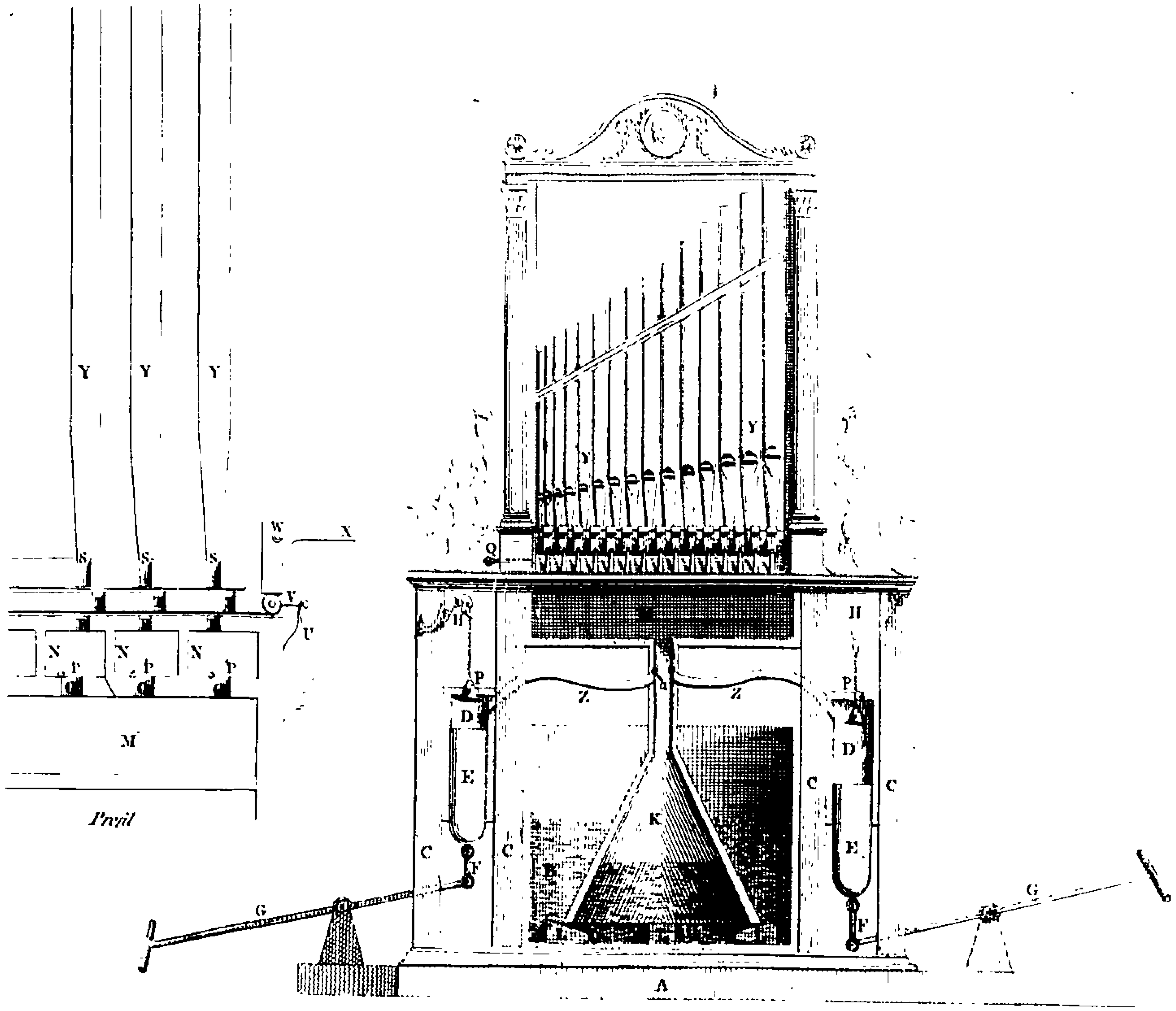


Fig. LXXXVII.

Fig. LXXXVI.





Profil

Fig. LXXXVIII.

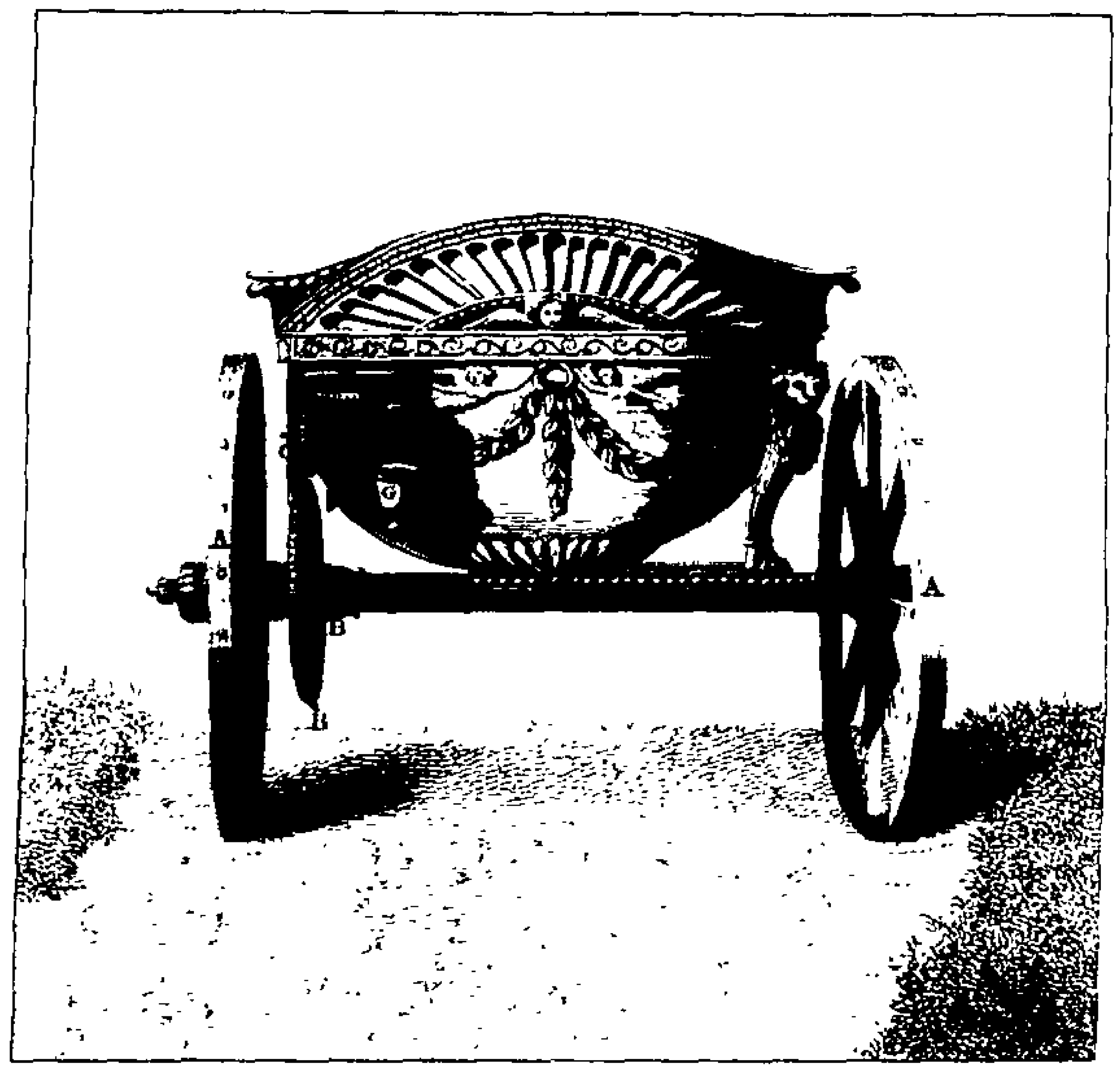


Fig. LXXXIX.

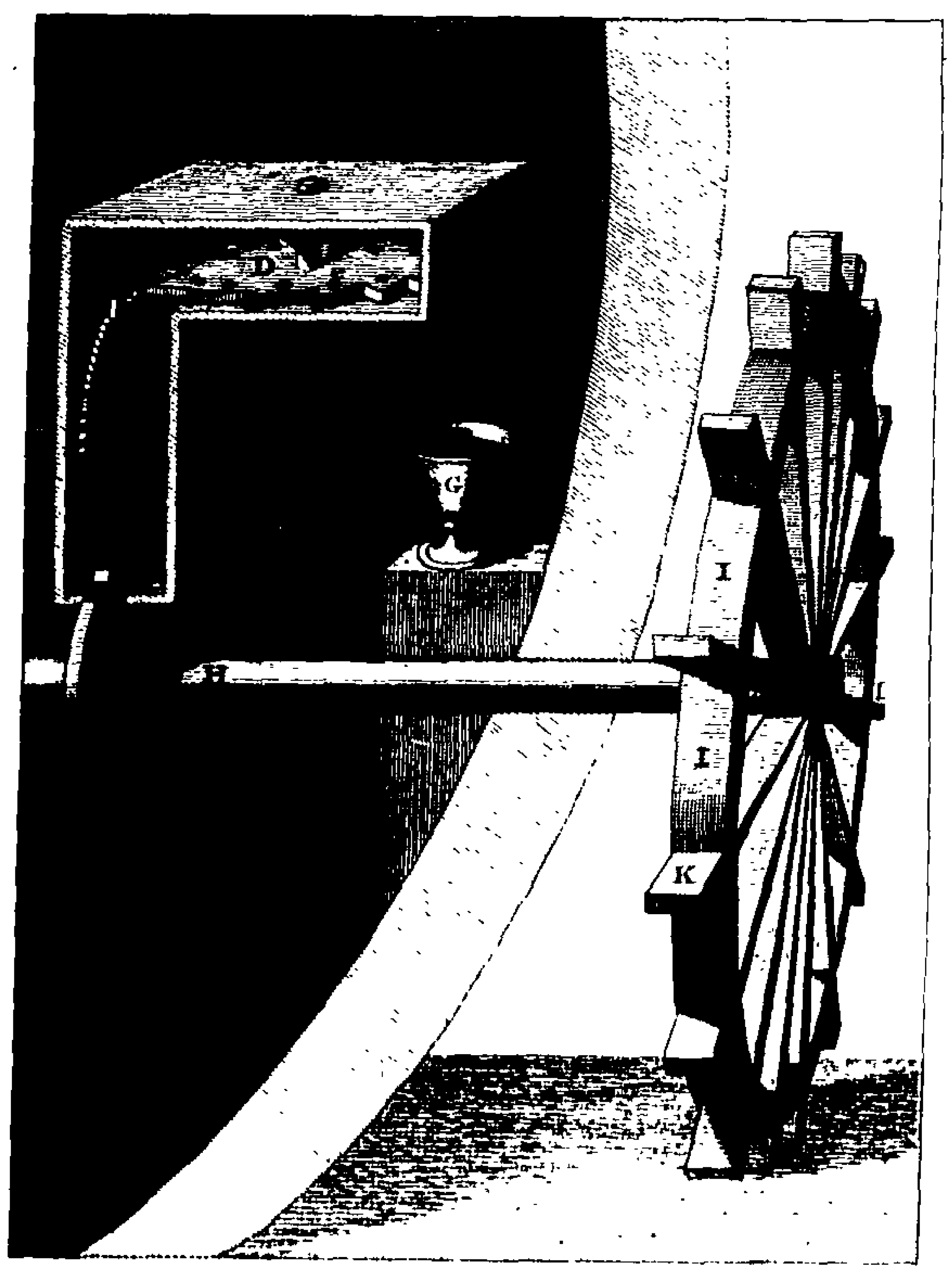


Fig. XC.

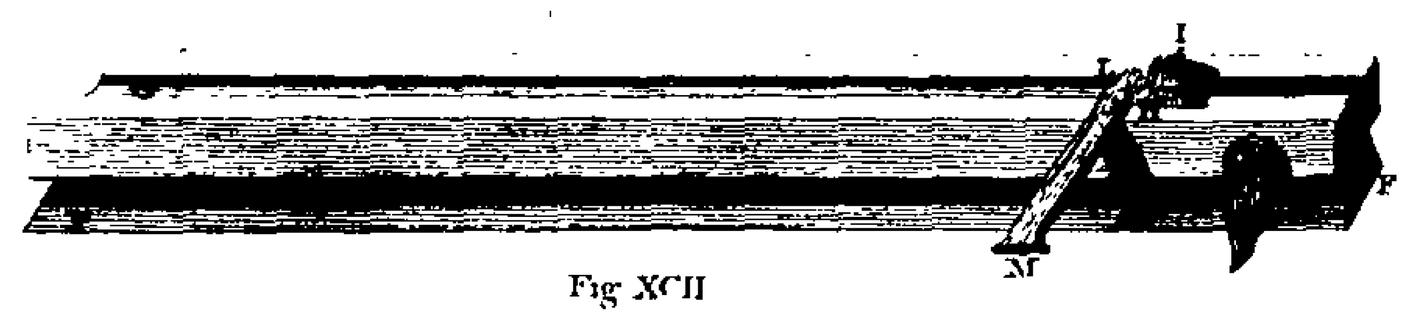


Fig XCII

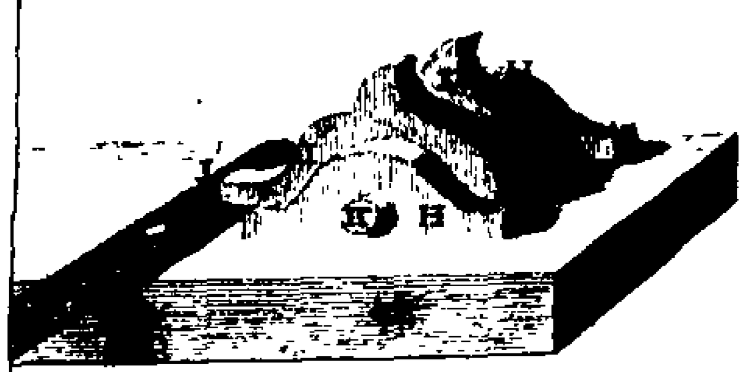


Fig XCIII

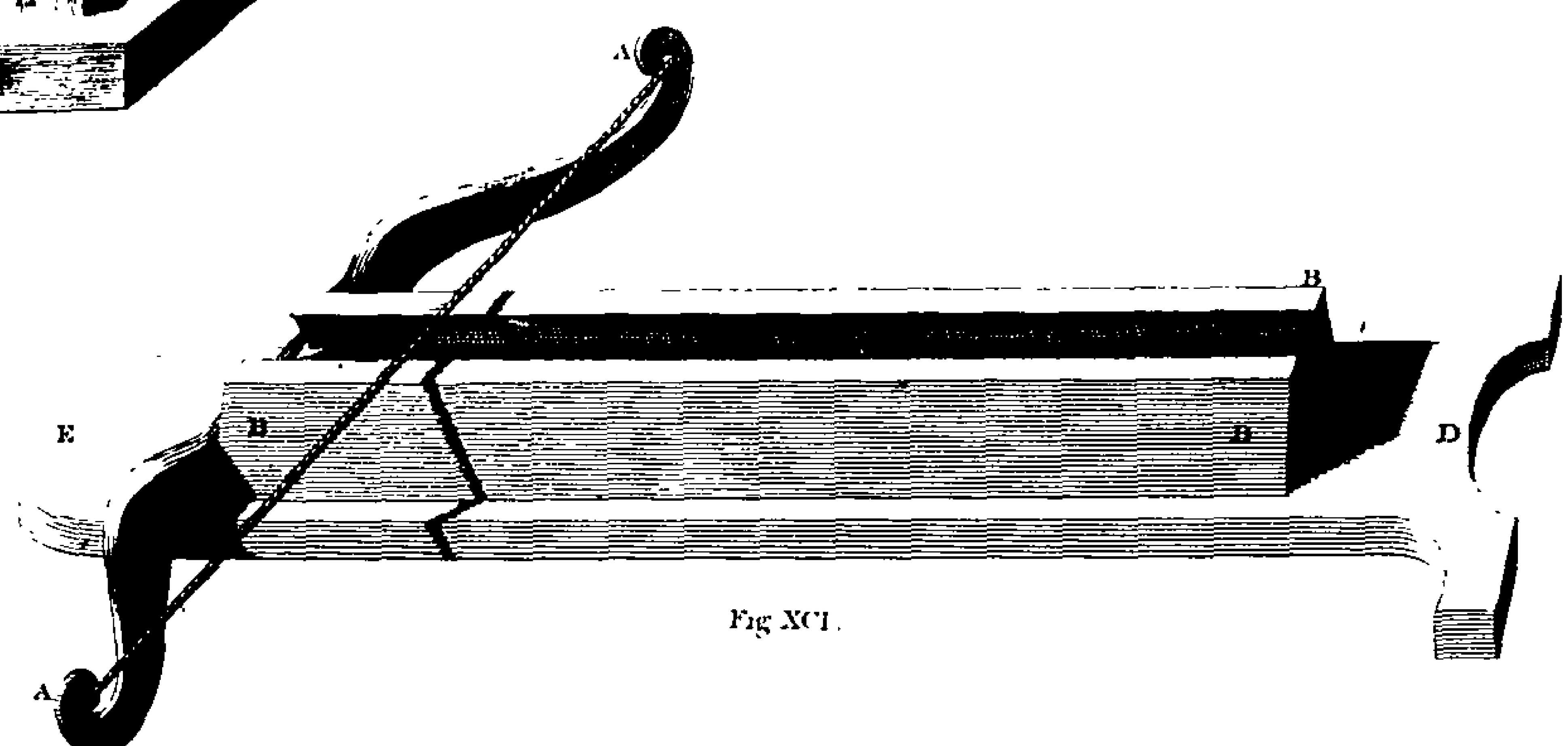


Fig XCI.

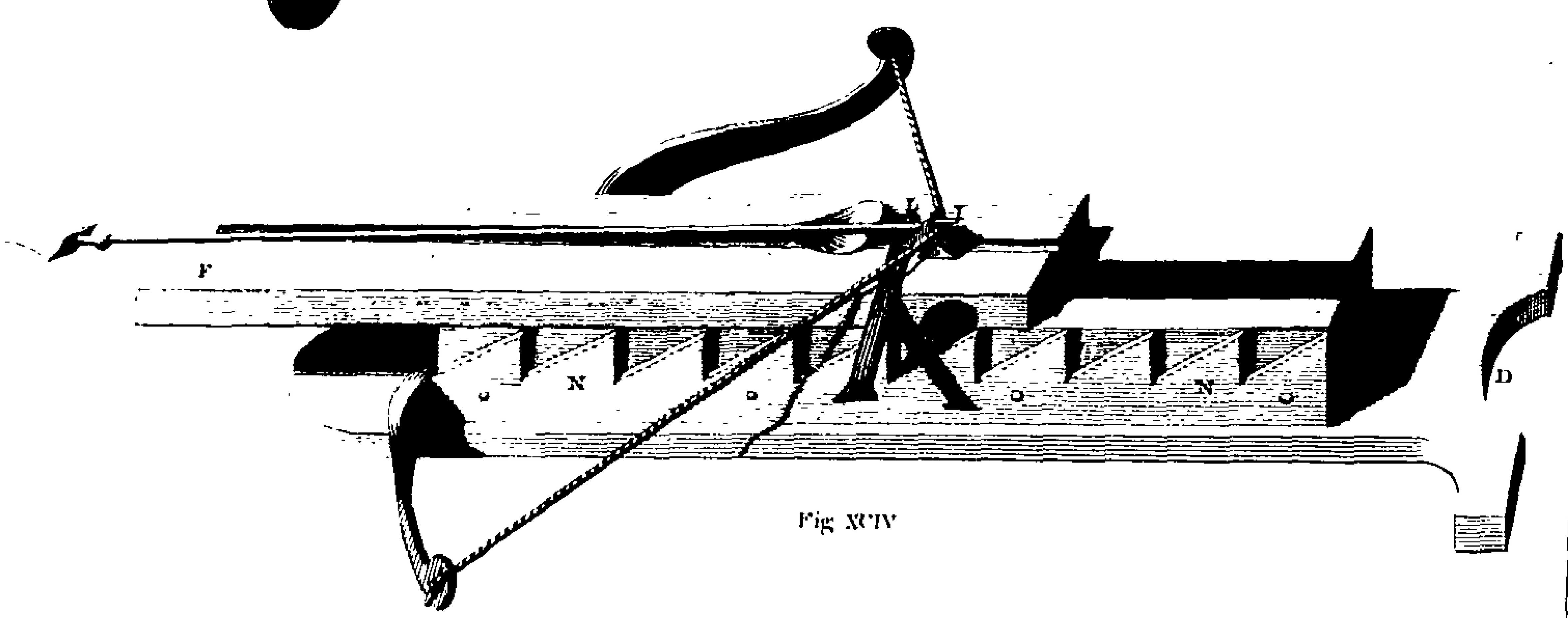


Fig XCIV

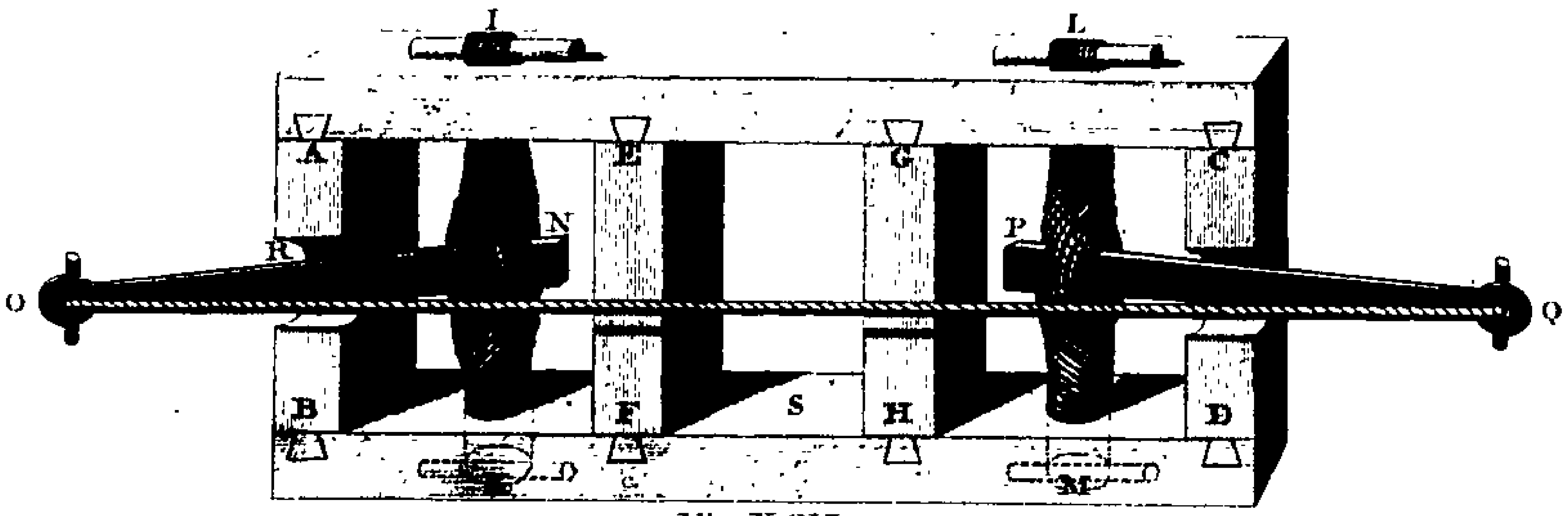


Fig. XCV.

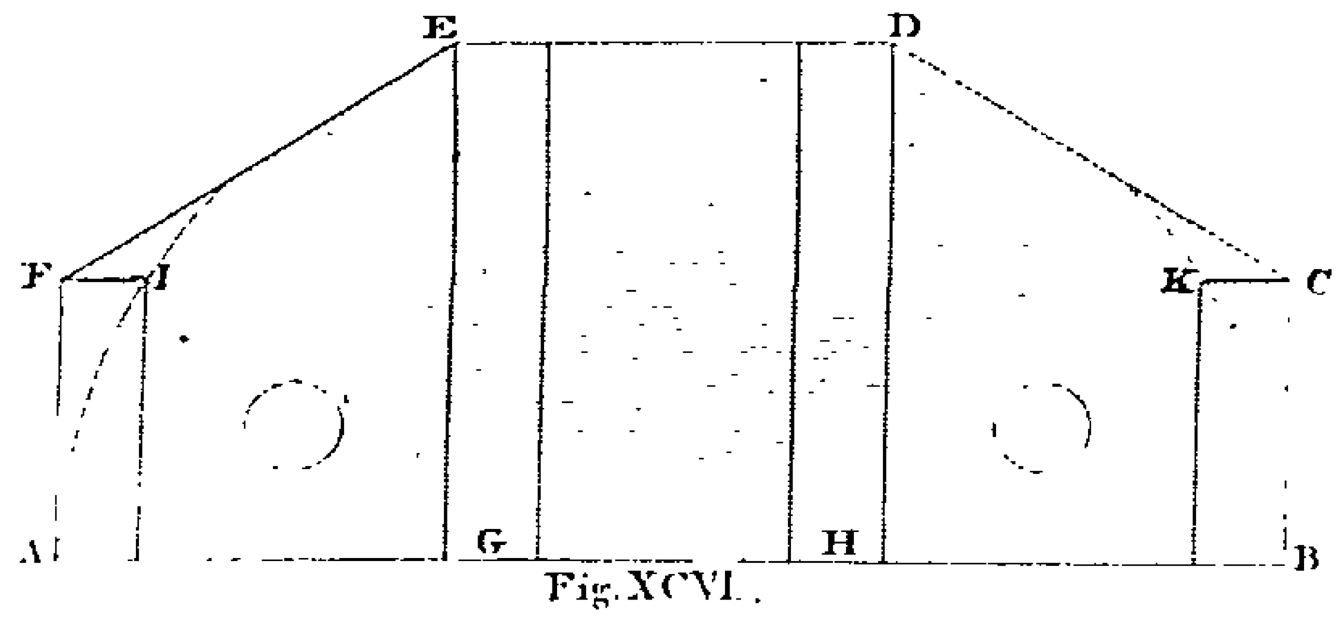


Fig. XCVI.

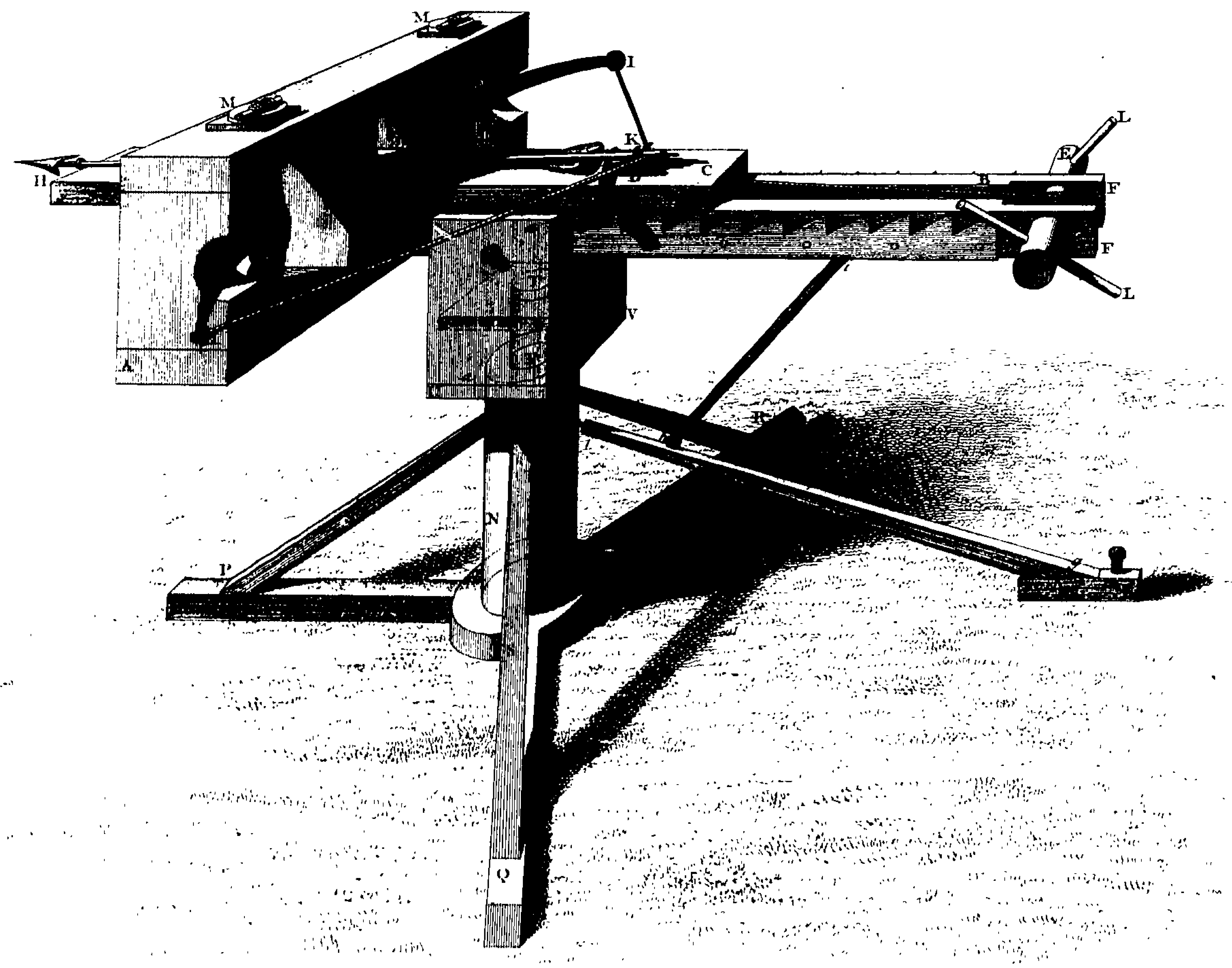


Fig. XCVII.

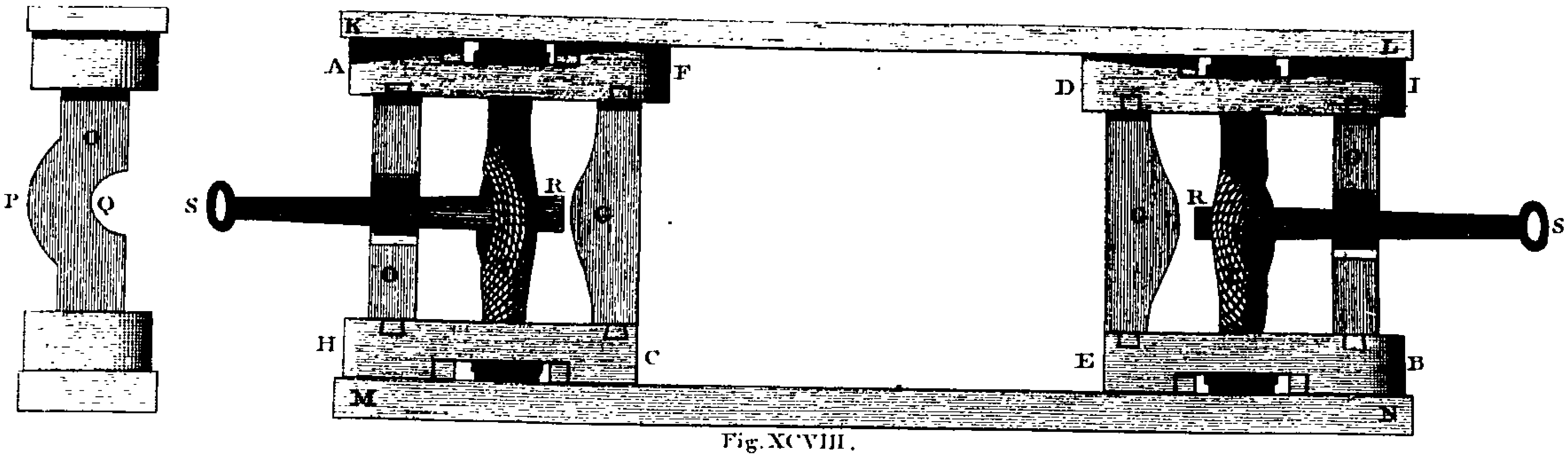


Fig. XCVIII.

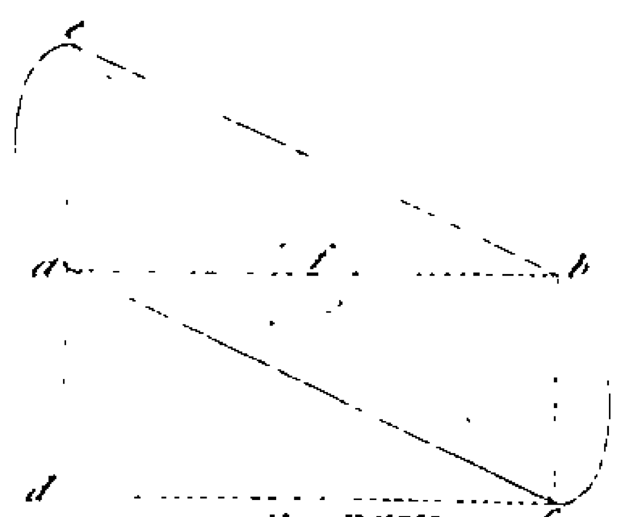


Fig. XCIX.

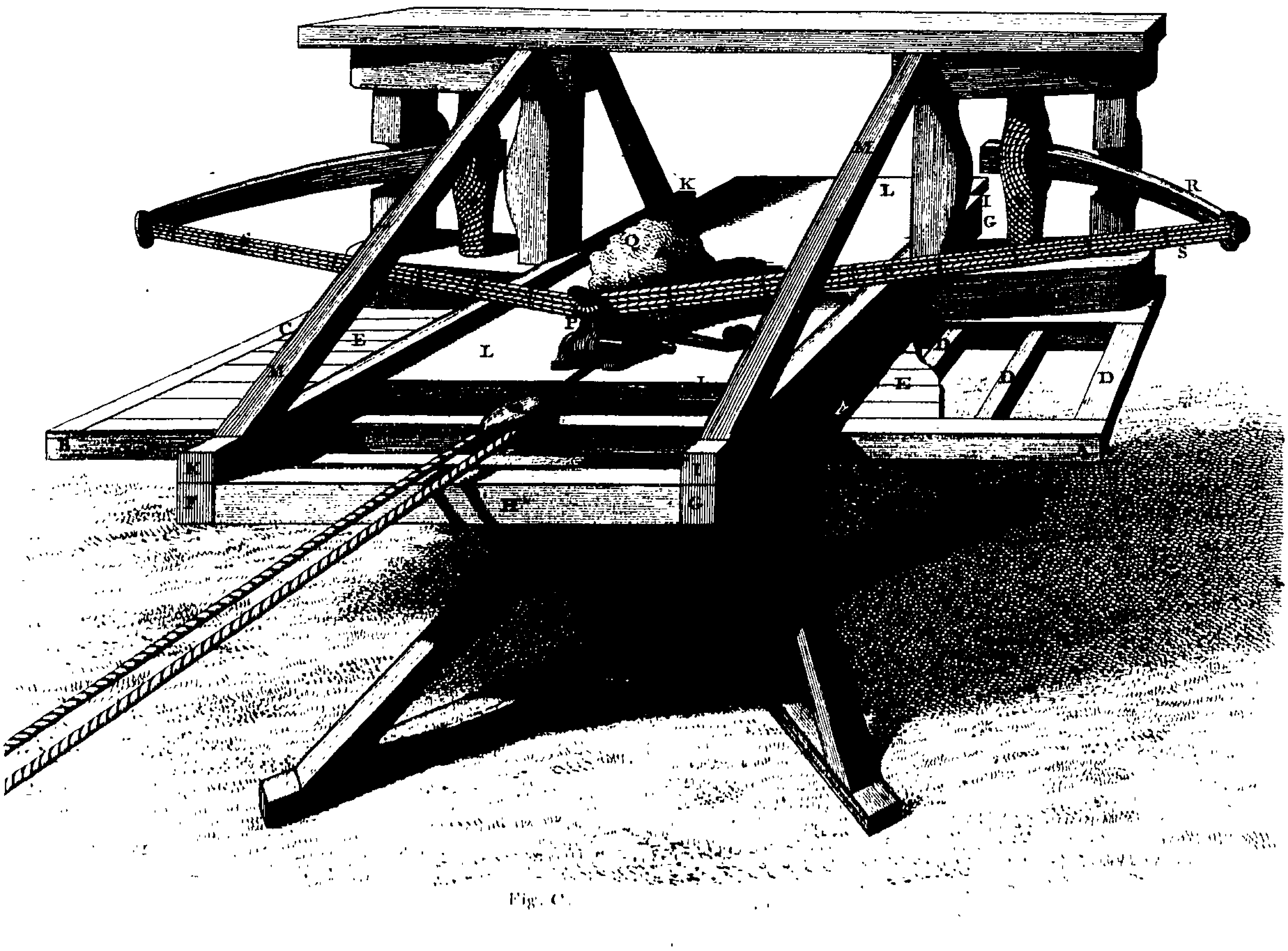


Fig. C.

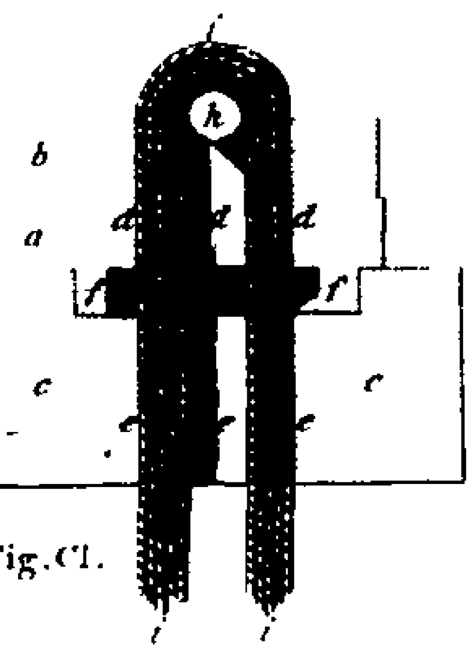


Fig. CI.

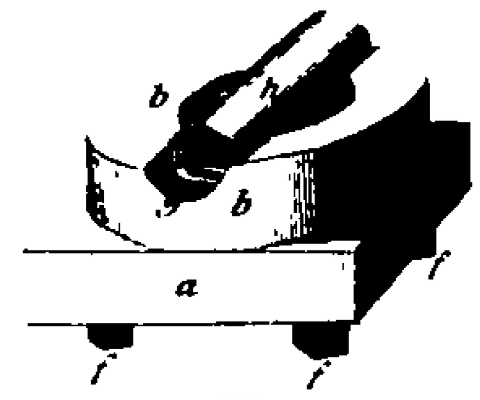


Fig. CII

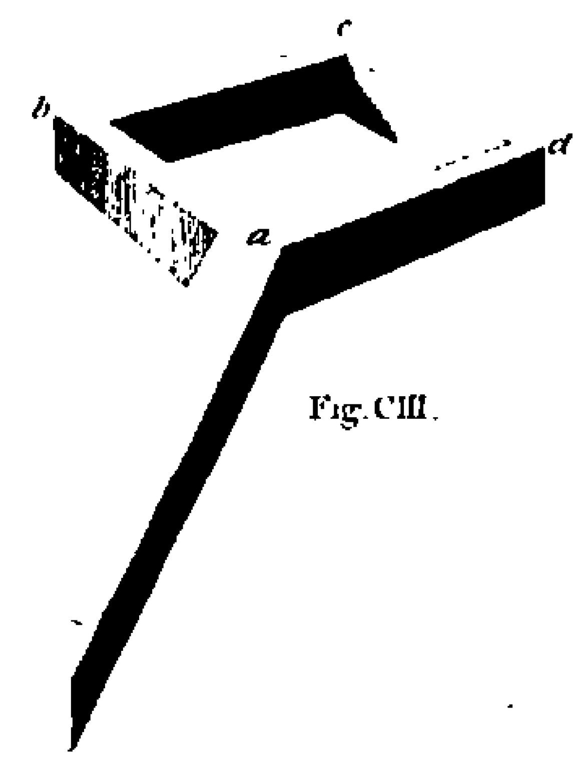


Fig. CIII.

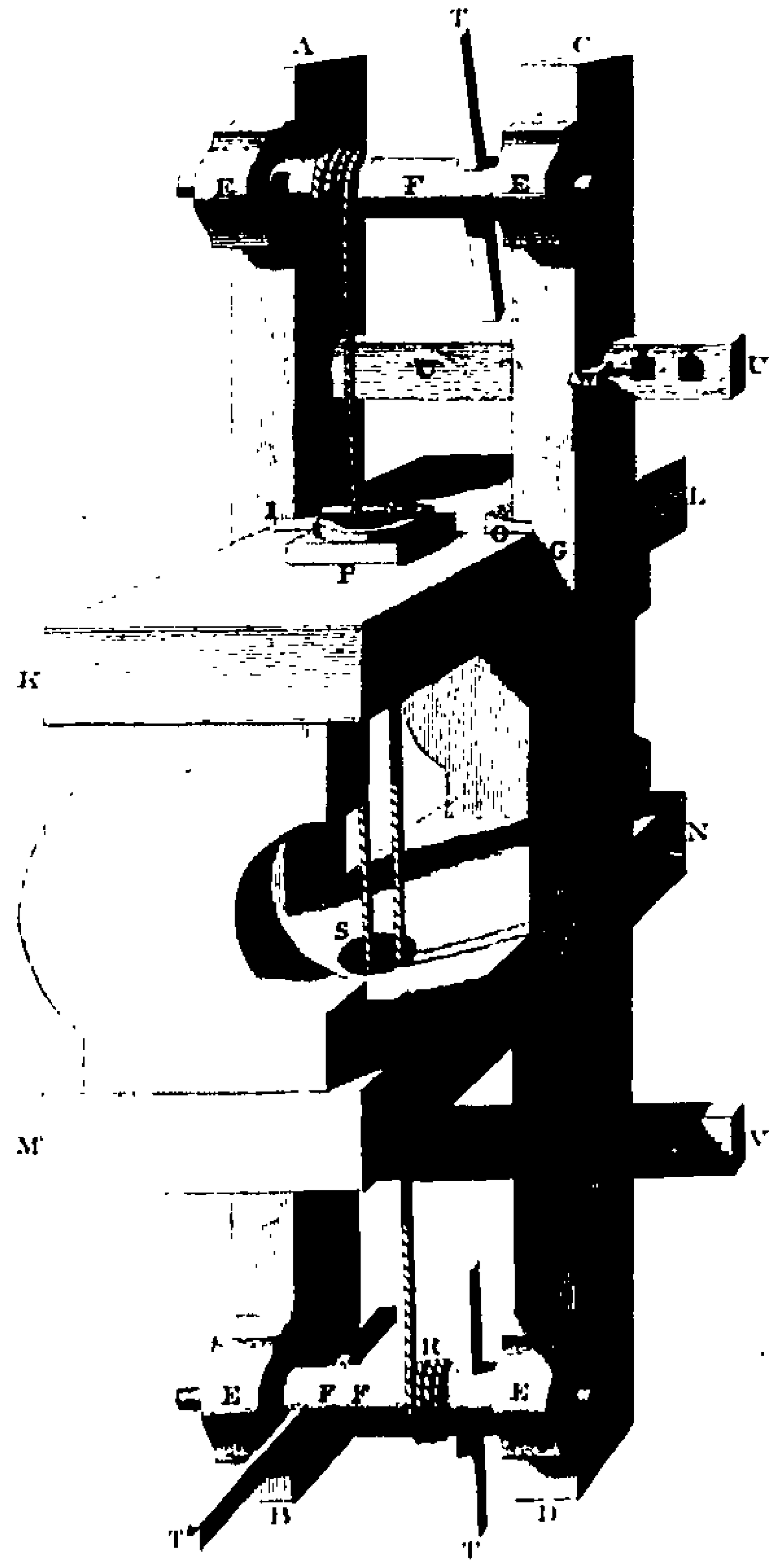


Fig. CIV

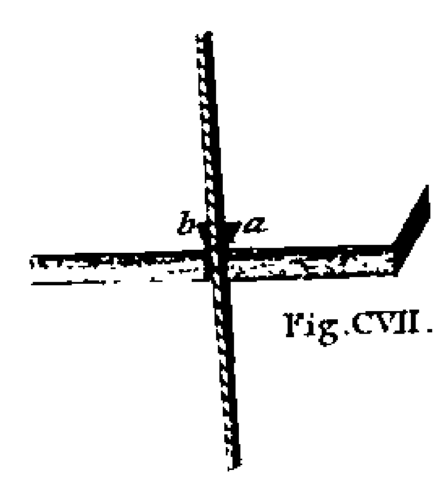


Fig. CVII.

Fig. CVI

Fig. CV.

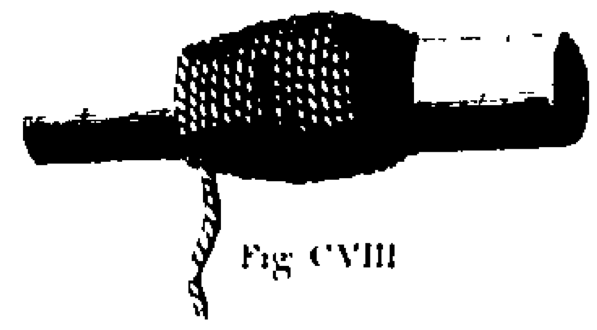


Fig. CVIII

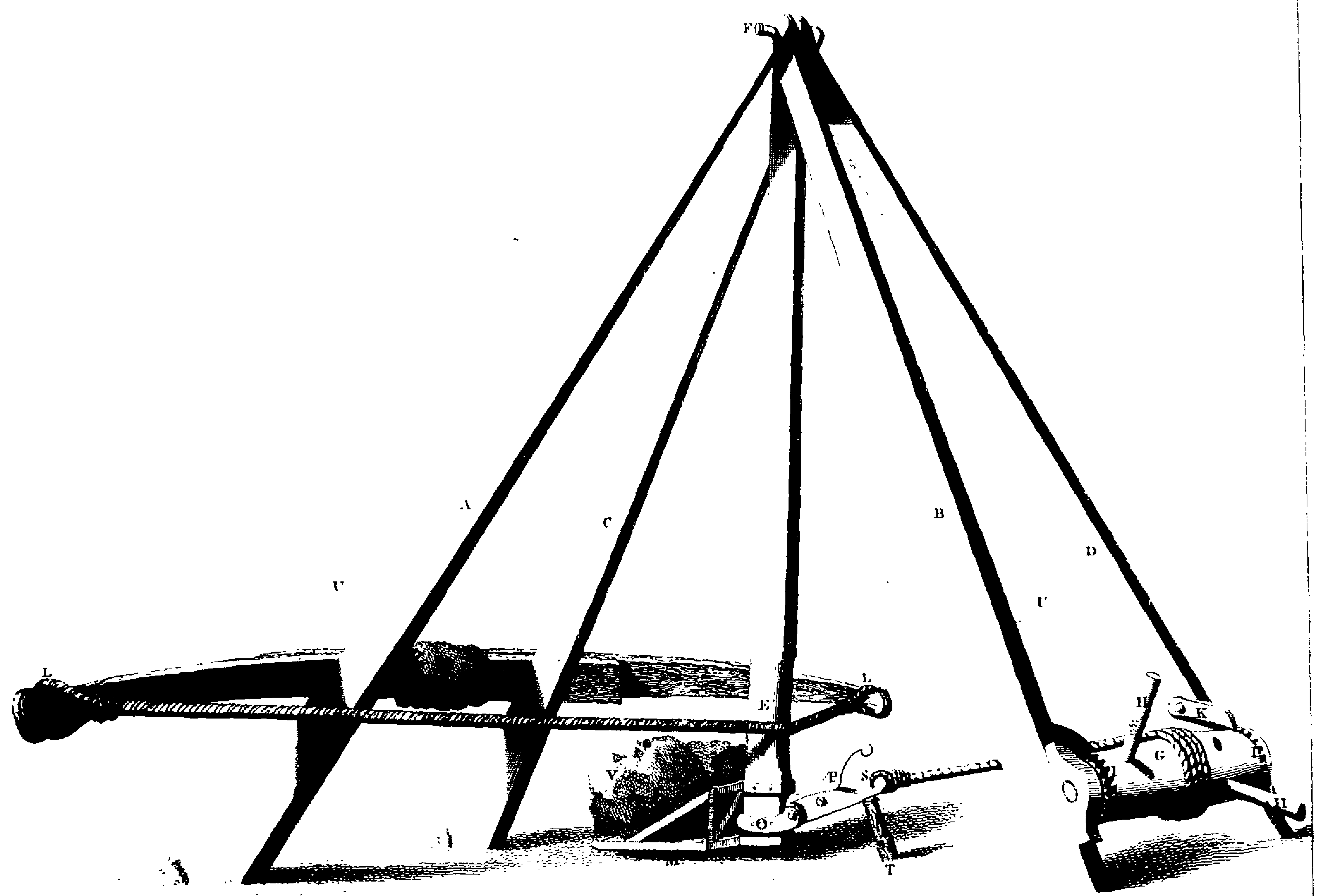
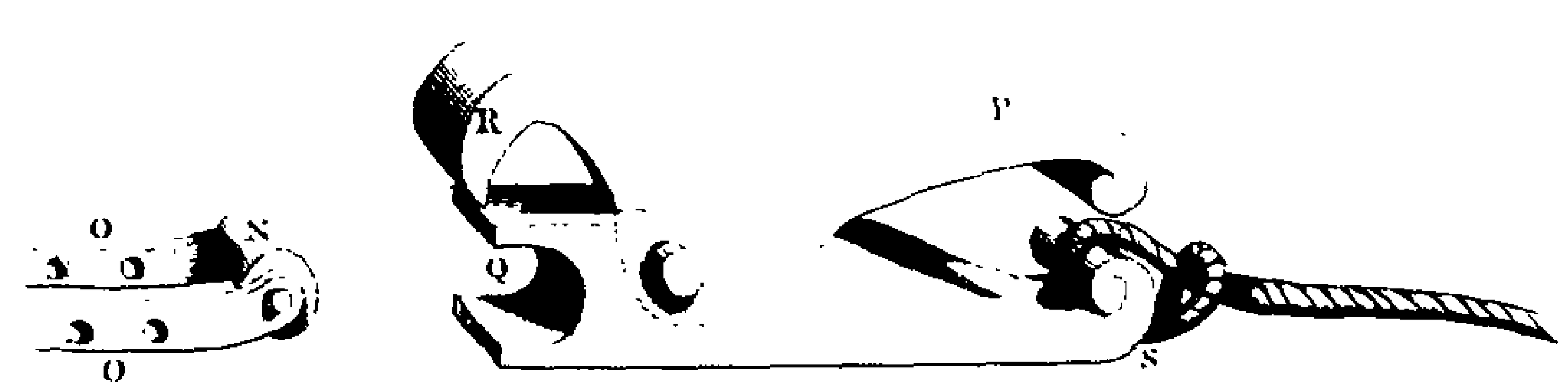


Fig. CVIII. N°2.



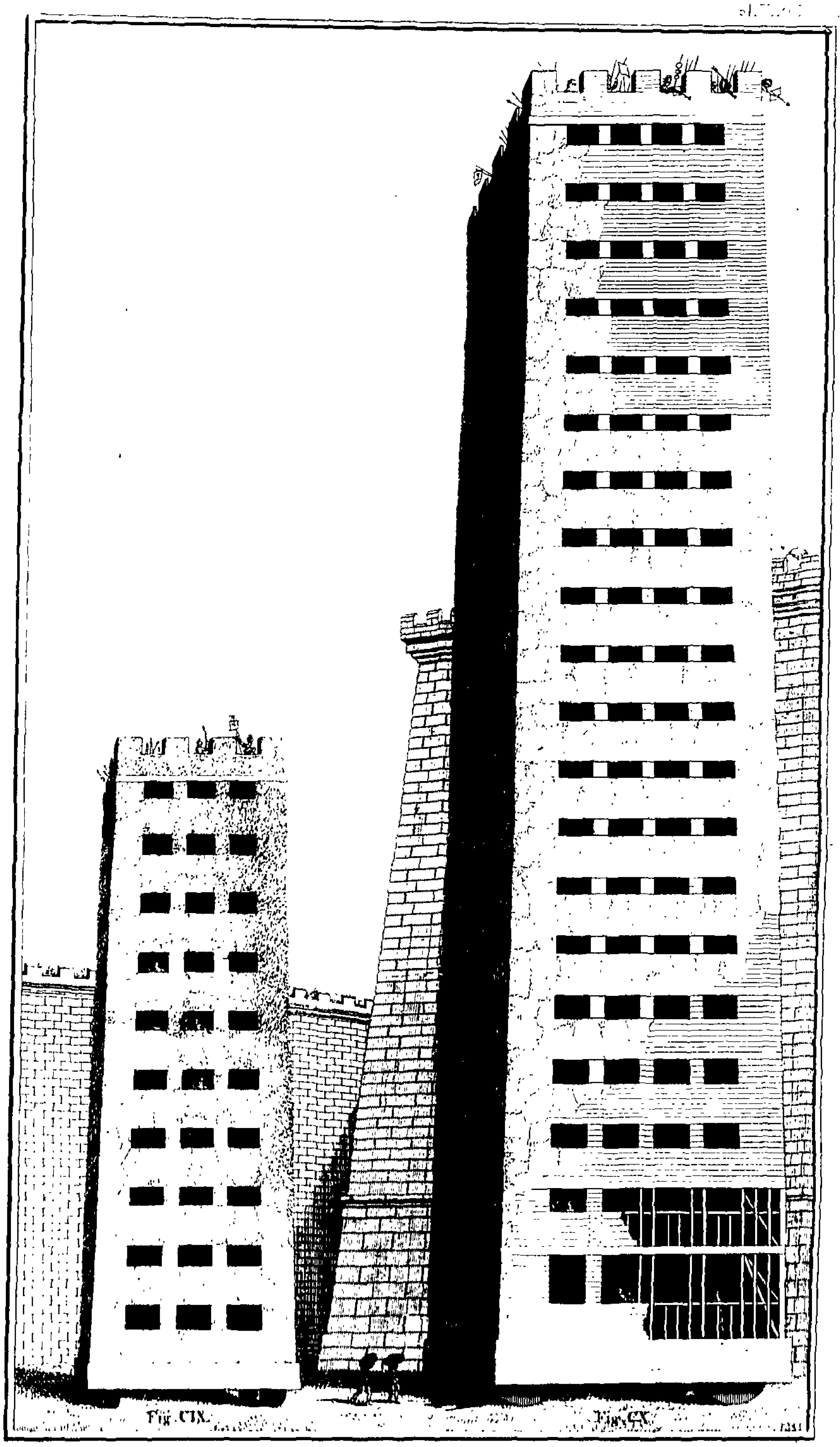


Fig. CIX.
Fig. CX.

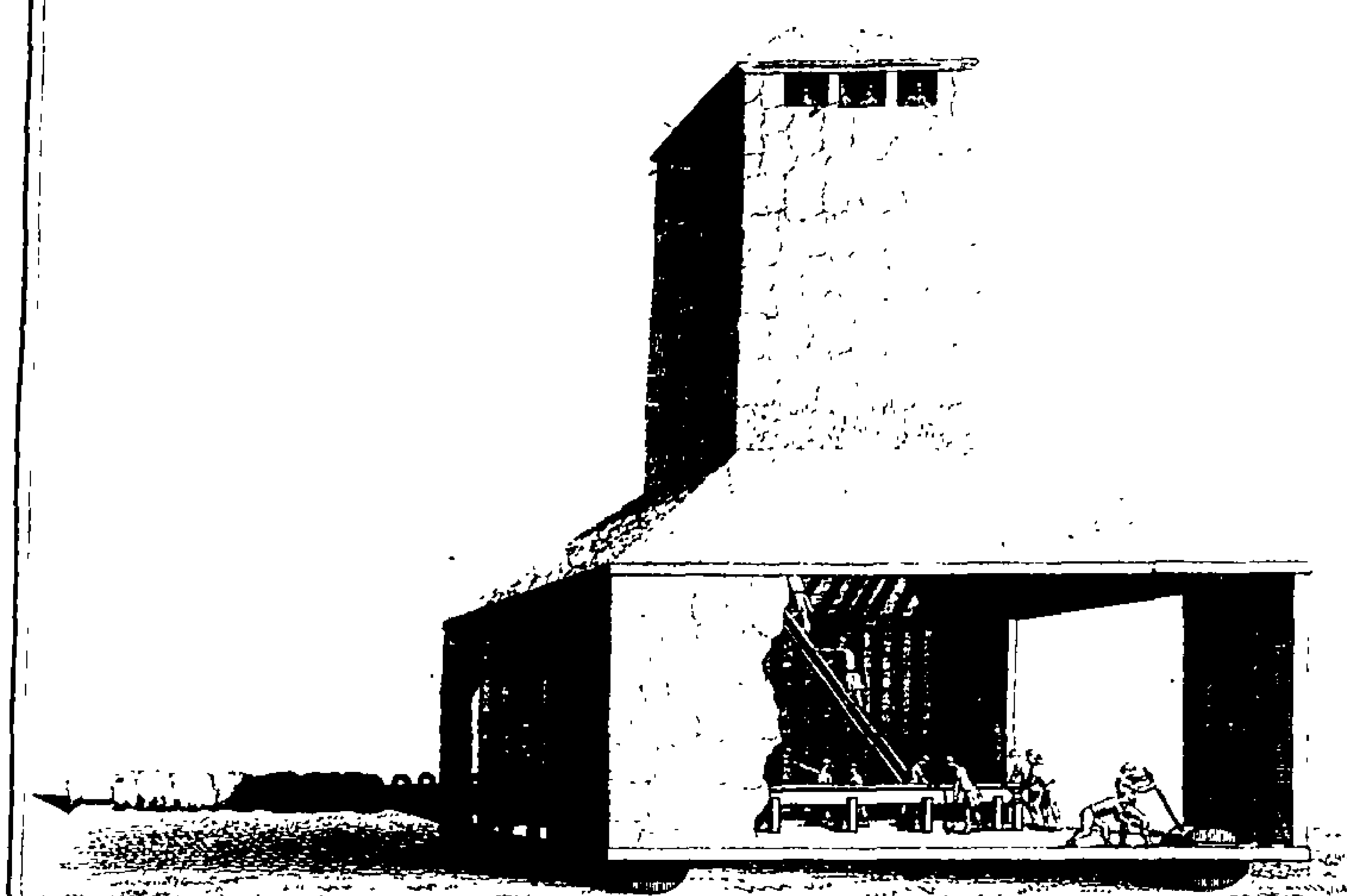


Fig. CXII.

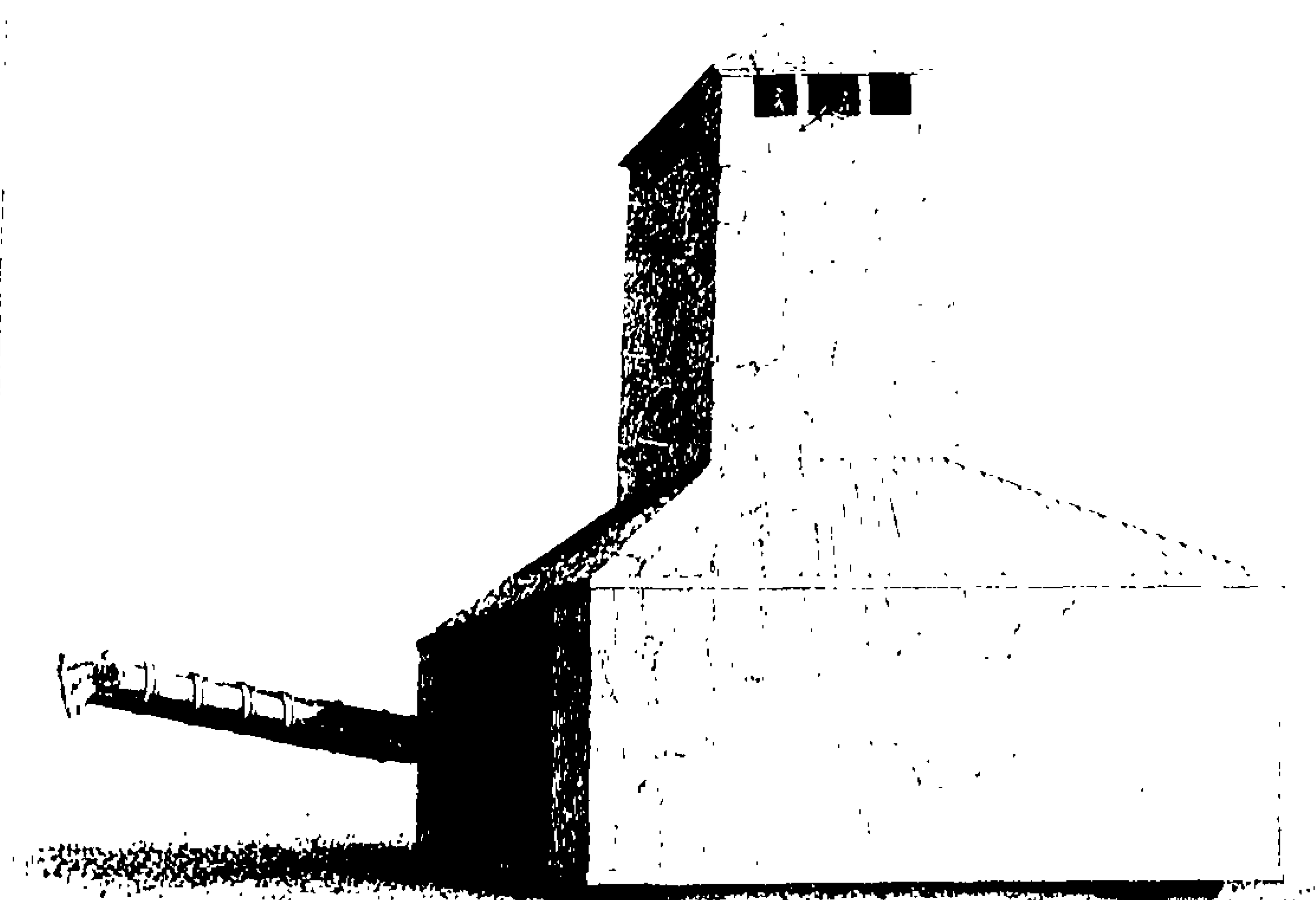


Fig. CXI.

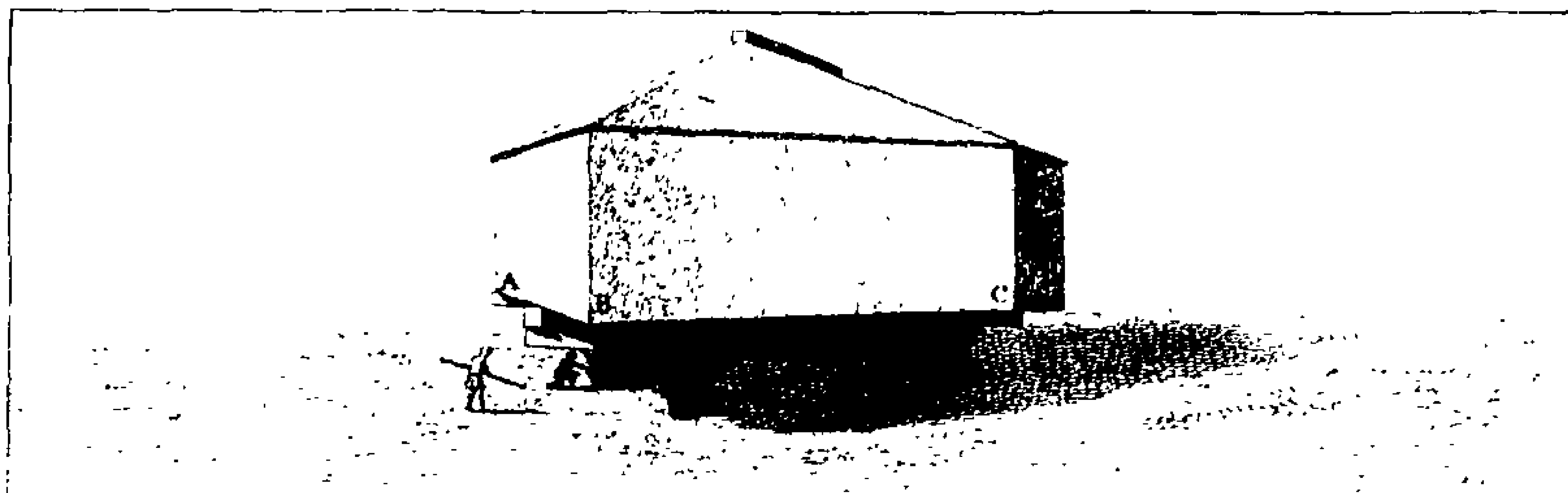


Fig. CXVI.

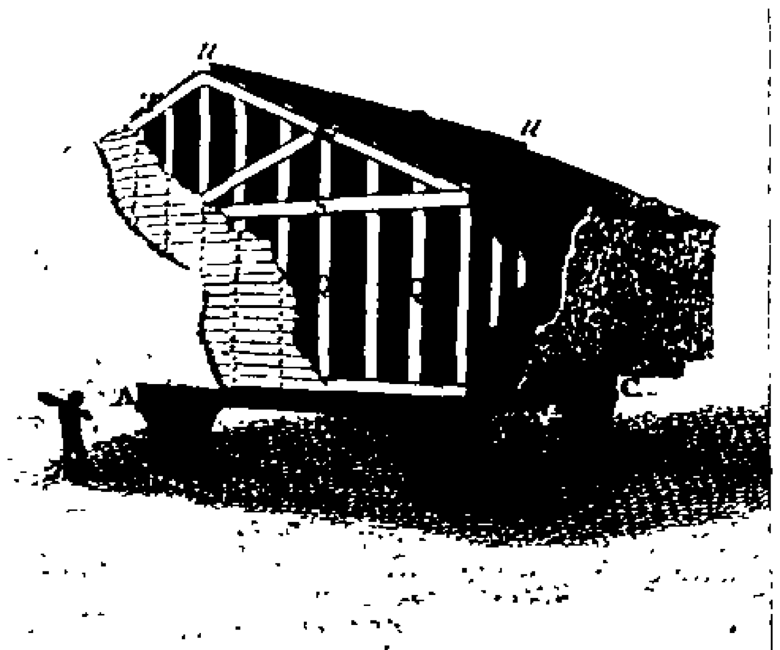


Fig. CXIII.

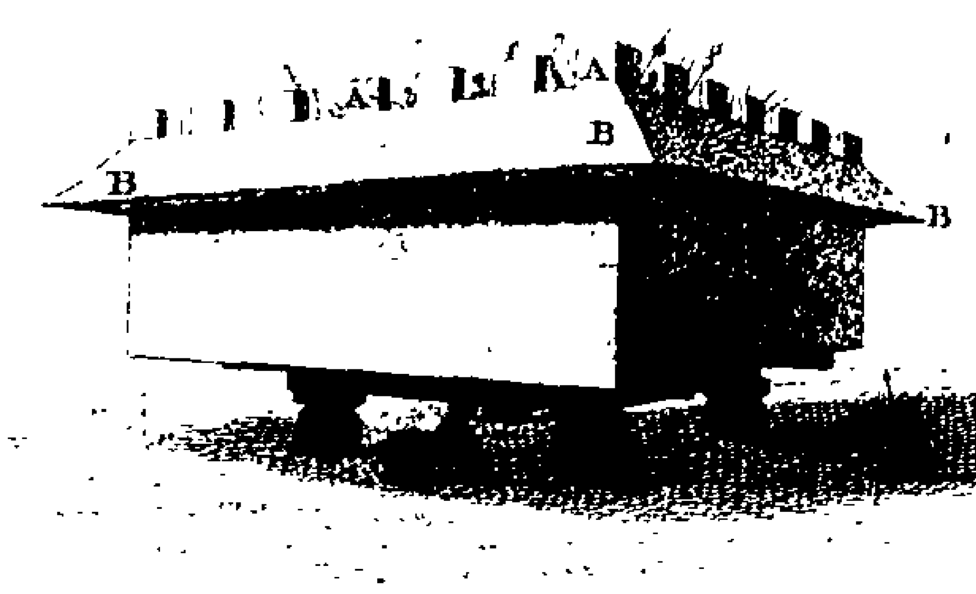
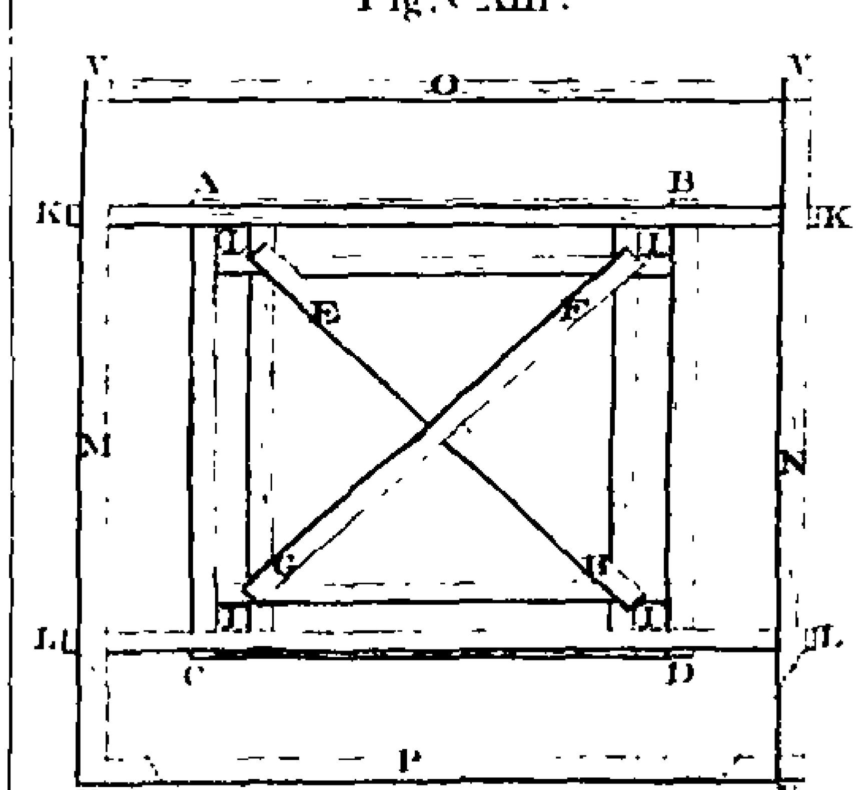


Fig. CXV.



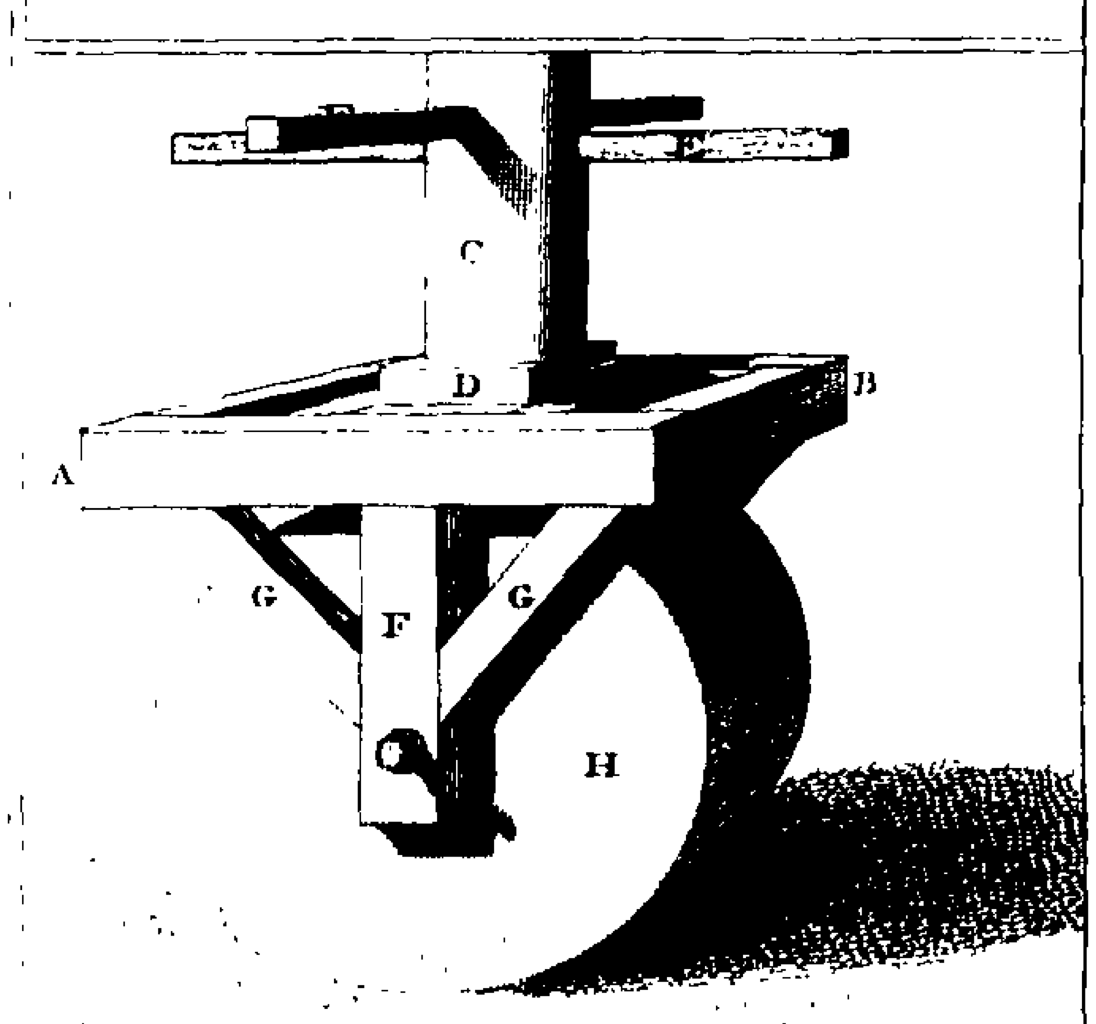


Fig. CXIV.

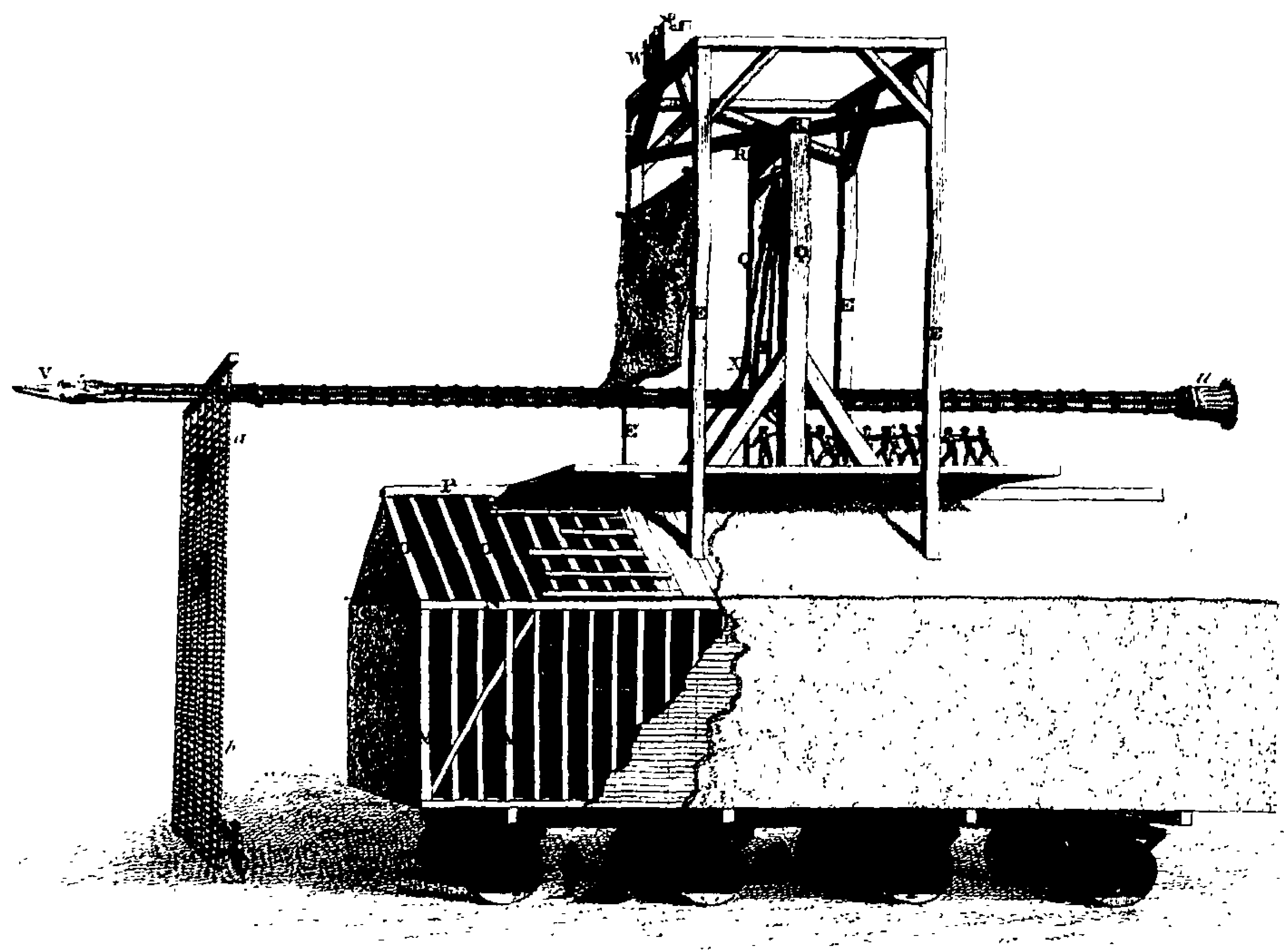


Fig. CXVII.